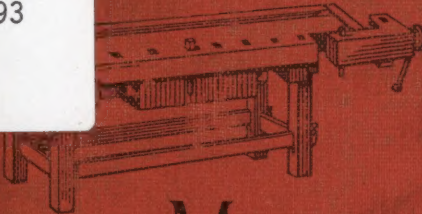
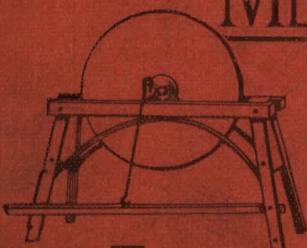
NDYBOOKS FOR HANDICRAFTS

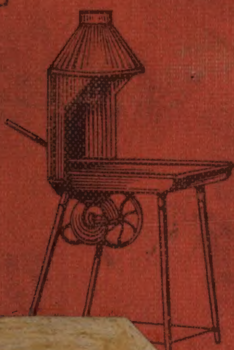
(ONE SHILLING)

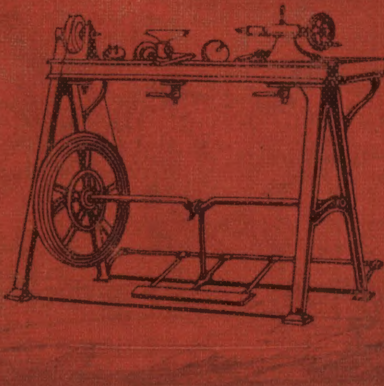


THE MECHANIC'S WORKSHOP HANDYBOOK



P. N. HASLUCK





· CROSBY LOCKWOOD & SON ·

Fifth Edition, Enlarged, with 380 Illustrations. 12mo, 3*s*. 6*d*. cloth.

VENTILATION: A Text-Book to the Practice of the Art of Ventilating Buildings. By WILLIAM PATON BUCHAN, R.P., Sanitary Engineer. With 170 Illustrations. 12mo, 3*s*. 6*d*. cloth.

GAS FITTING: A Practical Handbook treating of every Description of Gas Laying and Fitting. By JOHN BLACK. With 120 Illustrations. 12mo, 2*s*. 6*d*. cloth.

CROSBY LOCKWOOD & SON, 7, Stationers' Hall Court, E.C.

THE

MECHANIC'S WORKSHOP

HANDYBOOK.

THE

MECHANIC'S WORKSHOP HANDYBOOK.

A Practical Manual

ON

MECHANICAL MANIPULATION:

EMBRACING INFORMATION ON VARIOUS HANDICRAFT PROCESSES, WITH USEFUL NOTES AND MISCELLANEOUS MEMORANDA.

BY

PAUL N. HASLUCK,

AUTHOR OF "LATHE WORK," "THE METAL TURNER'S HANDYBOOK," "THE WOOD TURNER'S HANDYBOOK," ETC.

Second Edition.

LONDON:

CROSBY LOCKWOOD AND SON,

7, STATIONERS' HALL COURT, LUDGATE HILL.

1893.

PUBLISHERS' ADVERTISEMENT.

THIS handy book is designed for the help and guidance of young mechanics and others interested in the manipulation of metal. It begins, therefore, with some account of the constituents and characteristics of the metals and alloys familiar to the mechanic in his daily work, and then proceeds to give practical teaching and counsel on various processes and operations which go to make up the occupation of workers in metal. Special attention is given to the handling and treatment of various tools. Being an outcome of practical experience, the book cannot fail to be useful to the young aspirant who aims at an intelligent appreciation of the "why" and the "wherefore" of the work he has to do; and it is believed, also, that it will prove helpful to like-minded workers of all ages and degrees of experience.

A glance at the very full Index will show that there is to be found in the following pages a much larger variety and extent of detail than might be expected in a work of such modest dimensions.

CONTENTS.

CHAP.		PAGES
I.	METALS AND ALLOYS	1—15
II.	IRON AND ITS TREATMENT	16—25
III.	STEEL AND ITS TREATMENT	26—43
IV.	BRASS AND ITS TREATMENT	44—55
V.	SOLDERS AND SOLDERING	56—69
VI.	FILES AND FILING	70—87
VII.	TOOL GRINDING	88—103
VIII.	DRILLS AND DRILLING	104—119
IX.	ABRASIVE AND FINISHING PROCESSES	120—130
	INDEX	131—136

THE

MECHANIC'S WORKSHOP HANDYBOOK.

CHAPTER I.

METALS AND ALLOYS.

THE metals constitute about five-sixths of the known elementary bodies. They are distinguished by a peculiar lustre, by their opacity, and by their power of conducting heat and electricity. With few exceptions, metals possess considerable specific gravity, hardness and cohesion, and require a high degree of heat to liquefy them. One, mercury, is liquid at ordinary temperatures; and a very few, as sodium and potassium, are lighter than water, which they decompose with such energy as to produce combustion.

The properties which characterise metals, and by which distinctive qualities are shown, are tabulated on page 2.

The various figures are collected from a multitude of sources, the best attainable. The authorities often differ somewhat widely, but this can be accounted for from the fact that few metals are obtained pure. The peculiarities in the same metals obtained from different localities are often unnoticed, and account for the variable statements of the cohesion in the tables compiled by those who have investigated the properties of metals and published the results.

THE PROPERTIES AND CHARACTERISTICS OF METALS.

NAME.	Symbol.	Tensile Strength. Lbs. per square in.	Atomic Weight.	Specific Gravity: Water = 1·	Melts—Deg. Fahr.	Specific Heat.	Linear Expansion from 32° to 112° Fah.	Mag. or Diamag.	Relative Order.					
									Mag. or Diamag.	Malleability.	Ductility.	Conductivity. Heat.	Conductivity. Electricity.	Tenacity—Wire $\frac{1}{10}$ in. Diam. sustains lbs.
Aluminium	Al.		27·49	2·67	1,562	·2143				7	10	66		
Antimony	Sb.	1,060	122	6·71	797	·0508	$\frac{1}{923}$	D	2			21	5	
Arsenic	As.		75	5·8		·0814		D	12				5	
Bismuth	Bi.		210·34	9·823	500	·0308	$\frac{1}{719}$	D	1			6	1	
Cadmium	Cd.		112·12	8·655	617	·0567		D	5	11	7	58	24	
Chromium	Cr.		52·5	6·81	3,992			M	5					
Cobalt	Co.		58·8	8·95	3,272	·1069		M	3	13	8		17	
Copper	Cu.	33,000	63·49	8·95	1,742	·0950	$\frac{1}{582}$	D	10	3	5	84	99	600
Gold	Au.		196·66	19·34	2,282	·0324	$\frac{1}{661}$	D	11	1	1	98	78	200
Iridium	Ir.		197·1	21·15	3,992	·0326		D	15					
Iron	Fe.	57,600	56·08	7·844	2,912	·1138	$\frac{1}{812}$	M	1	6	4	44	17	720
Lead	Pb.	1,900	206·91	11·36	617	·0314	$\frac{1}{351}$	D	8	10	13	29	8	18
Magnesium	Mg.		24·6	1·743	1,382						15			
Manganese	Mn.		55·7	8·013	3,452	·01217		M	4					
Mercury	Hg.		200	13·596	—40	·0318		D	7				2	
Nickel	Ni.		58·8	8·82	2,912	·1086		M	2	12	9		13	
Palladium	Pd.		106·47	11·8	3,632	·0593	$\frac{1}{1000}$	M	8	5	6		18	280
Platinum	Pt.		197·1	21·5	3,992	·0324	$\frac{1}{1131}$	M	9	4	3	38	18	560
Potassium	K.		39·13	·865	131	·1695								
Rhodium	Ro.		104·3	12·1	4,352	·0580		D	14					
Silver	Ag.		107·93	10·53	1,832	·0570	$\frac{1}{524}$	D	9	2	2	100	100	400
Sodium	Na.		23·04	·972	194	·2934		D	6			36		
Tin	Sn.	4,700	118·	7·294	428	·0562	$\frac{1}{516}$	D	4	8	12	42	12	48
Tungsten	W.		184·	17·6	4,352	·0334		D	16					
Zinc	Zn.	7,500	65·04	7·146	707	·0955	$\frac{1}{340}$	D	3	9	11	64	29	75

This list does not include a number of rare Metals which are known only in the laboratory, and have little importance as yet in the arts.

Iron and steel, though strictly alloys, are usually spoken of by the mechanic as metals; and none are so valuable as these. A few words on their origin and production will be read with interest by all mechanicians who desire to learn the operations involved in the manufacture of the materials which they are constantly using, not only for the construction of every description of mechanism, but also in the form of tools and appliances by which rough metal is wrought to shape.

Pure metallic iron has but little commercial use, and in this state is comparatively unknown; it is when combined with carbon, sometimes modified by other elements, that pure iron becomes the iron of commerce, and is known as malleable iron, steel, and cast iron, as the proportion of carbon is increased. Pure iron may be obtained by placing a mixture of magnetic oxide of iron and fragments of commercial iron, such as filings, in a crucible, and heating to a white heat—the crucible being meanwhile covered. The pure iron thus obtained is softer than ordinary soft malleable iron; it is very tenacious and ductile, and its malleability is not affected by heating and suddenly cooling. Though it does not retain magnetism, its magnetic power is very high. The more free from impurities, the higher will be the electrical conductivity of the metal and the greater the heat required for its fusion—admixture of carbon reducing the point at which pure iron melts, which is but little below the melting-point of platinum. Though unaffected by dry air at ordinary temperatures, iron, when in a state of very fine division, is liable to spontaneous combustion.

Heated in contact with the atmosphere, as at the ordinary smith's forge, layers of scale form on the exposed surface, which easily detach themselves if the bulk is hammered; the outer scale is fusible only at a very high temperature; it is very brittle and highly magnetic. Malleable iron and steel

have a curious property imparted to them when united with sulphur, to which they have great affinity; a very small percentage has the effect of rendering the metal "red short"—that is unworkable at a red heat—whilst it may be wrought with facility when cold. The addition of copper has a similar effect. The reverse effect results from the presence of phosphorus, an infinitesimal proportion causing marked alteration in the working qualities of the metal; the tenacity is very sensibly impaired by even a half per cent., and the metal shows decided signs of being "cold short"—that is, unworkable in a cold state—but when heated it may be worked easily.

It is chiefly by the admixture of carbon that iron becomes the useful well-known iron and steel which are familiar in workshop practice. Carbon and iron do not combine at ordinary temperatures; but when raised to redness and above that heat, combination is effected with more or less rapidity. In cast iron, the proportion of carbon may be something like five per cent., the quantity gradually decreasing in cast steel, shear steel and iron, in which the presence of carbon may be but barely traceable; the addition of sulphur, phosphorus, silicon and manganese to carbonised iron is usually practised in the course of manufacture with the object of obtaining results such as have been previously pointed out.

The treatment of iron ore in furnaces has generally for its object the production of pig iron, which is a material yet unfit for working. It cannot be welded, and, in fact, cannot be wrought with the hammer at all. This pig iron has always an admixture of some foreign material, and is charged with carbon to a large percentage. When carbon exists in but very small proportion, the metal is malleable or wrought iron—that is, the iron of commerce—varying in quality and physical structure according to the constituents and the treatment they have received. When melted and allowed to cool, the fracture

is crystalline or granular, assuming a fibrous structure after having been rolled or hammered, this process giving at the same time a great increase in tenacity. The melting-point of malleable iron is governed by the amount of carbon it contains; a large percentage of carbon rendering it more easily fused. Before this point is reached, the metal assumes a soft condition, and, when in that state, if two clean surfaces are brought in contact and adhesion forced, they will unite and form one solid piece. This process is termed "welding," and may be effected with ease by hammering when sufficiently hot any good malleable iron, though the presence of even minute proportions of foreign matters will sometimes prevent all efforts to weld. Metal which is "red short" will of course be practically unweldable. Hardness and brittleness are the effects of continued hammering on cold iron. When heated to whiteness, if exposed to air, the iron burns, and is rendered unfit for welding. In that state, it is called "burnt iron." All malleable iron is strongly affected by magnetism, but will not retain magnetic power.

Bar iron is supplied in various grades, the commonest being that which has been but once passed through the rolling mills; the next quality is that produced by taking lengths of No. 1 and welding them together to form a solid bar made up of several; this process is repeated to produce better, and so on. The continued repetition of the processes of welding and rolling renders the metal more ductile and in every way better fitted for engineering purposes. This system is most completely developed in the process called "faggoting," which consists of binding a large number of small bars together in the form of a faggot and heating the whole to welding temperature, and consolidating the mass by hammering. Carriage axles are so made; and for the production of gun barrels and the best class of iron lathe-mandrels the plan is still further developed.

Steel, which is so abundantly used by the mechanic for the manufacture of the tools used for all purposes, is, in its physical structure, midway between malleable iron and pig iron. Malleable iron has a percentage of from the merest trace to ·3 of carbon, though this latter combination will be metal of decidedly steely characteristics, and whether to be classed as iron or steel will be dependent on the presence of other materials which influence the one which predominates. A proportion of 2·0 per cent. of carbon will produce pig iron; the intermediate proportions in combinations resulting in steel proper, which partakes, more or less, of the characteristics of pig or of malleable iron as the presence of carbon decreases. The precise point at which metal ceases to be steel and becomes pig or malleable iron, as the case may be, is perhaps hard to determine, but a generally-accepted distinction is, that when heated to a full blood-red heat and plunged into cold water, *steel* becomes hardened; on iron the same process has not that effect. This fact of steel being rendered so extremely hard by such a simple process is a most important one, and at once places this metal foremost amongst those used for cutting-tools and implements of every description. The subject of hardening steel is treated upon in another chapter.

Dr. Percy, in his "Metallurgy of Iron and Steel," defines steel as iron containing a small percentage of carbon, the alloy having the property of taking a temper; others define as steel all alloys of iron which have been cast in malleable masses; and Sir Joseph Whitworth considered that steel should be defined mechanically by a coefficient representing the sum of its strength and ductility.

With the object of having universally-adopted names which should indicate the nature and the distinction between iron and steels, an International Committee, appointed at Phila-

delphia, resolved that the following should be recommended :—

1. That all malleable compounds of iron, with its ordinary ingredients, which are aggregated from pasty masses, or from piles, or from any form of iron not in a fluid state, and which will not sensibly harden and temper, and which generally resemble what is called wrought iron, shall be called weld iron (German, *schweisseisen ;* French, *fer soude*).

2. That such compounds when they will from any cause harden and temper, and which resemble what is now called "puddled steel," shall be called weld steel (German, *schweiss stahl ;* French, *acier soude*).

3. That all compounds of iron, with its ordinary ingredients, which have been cast from a fluid state into malleable masses, and which will not sensibly harden by being quenched in water while at a red heat, shall be called ingot iron (German, *flusseisen ;* French, *fer fondu*)

4. That all such compounds, when they shall from any cause so harden, shall be called ingot steel (German, *fluss stahl ;* French, *acier fondu*).

The main line of demarcation here laid down lies in the capability to harden. Steel which will harden by heating to any temperature and using any quenching liquid is termed weld steel. That which will harden by being heated to redness and quenched in water is termed steel.

To obtain sound ingots of cast steel from high-class iron, it is necessary to boil the steel for some time after it has become fluid, and then allow it to cool to a certain temperature before it is poured into the mould. The process is called "killing" the steel, and it is an axiom that the higher the quality of the steel the more "killing" it takes. It is in this part of the process of melting crucible cast-steel that the virtue of the process consists ; and the cost and quality of the

cast steel produced depend in a large degree upon the skill brought to bear upon the killing.

Next to quality of steel, by which is meant the percentage of phosphorus, sulphur, silicon, manganese, &c., the most important thing is temper, or percentage of carbon. For many purposes, indeed, temper is of more importance than quality. Nothing is more common than for steel to be rejected as bad in quality because it has been used for a purpose for which the temper was unsuitable. The following is a list of the most useful "tempers" of cast steel :—

Razor Temper ($1\frac{1}{2}$ per cent. carbon).—This steel is so easily burnt, by being overheated, that it can be placed in the hands of only a very skilful workman. When properly treated, it will do twice the work of ordinary tool steel for turning chilled rolls, &c.

Saw-file Temper ($1\frac{3}{8}$ per cent. carbon).—This steel requires careful treatment; and, although it will stand more fire than the preceding temper, should not be heated above a cherry red.

Tool Temper ($1\frac{1}{4}$ per cent. carbon).—The most useful temper for turning tools, drills and planing-machine tools in the hands of ordinary workmen. It is possible to weld cast steel of this temper, but not without care and skill.

Spindle Temper ($1\frac{1}{8}$ per cent. carbon) —A very useful temper for mill-picks, circular cutters, very large turning tools, taps, screwing dies, &c. This temper requires considerable care in welding.

Chisel Temper (1 per cent. carbon).—An extremely useful temper, combining as it does, great toughness in the unhardened state with the capacity of hardening at a low heat. It may also be welded without much difficulty. It is consequently well adapted for tools, where the unhardened part is required to stand the blow of a hammer without chipping, but

where a hard cutting edge is required, such as cold chisels, hot setts, &c.

Sett Temper ($\frac{7}{8}$ per cent. carbon).—This temper is adapted for tools where the chief punishment is on the unhardened part, such as cold setts, which have to stand the blows of a very heavy hammer.

Die Temper ($\frac{3}{4}$ per cent. carbon).—The most suitable temper for tools where the surface only is required to be hard, and where the capacity to withstand great pressure is of importance, such as stamping or pressing dies, boiler-cups, &c. Both the last two tempers may be easily welded by a mechanic accustomed to weld cast steel.

There are also many peculiar kinds of steel, only some of which can obtain brief mention. A special steel for taps, called mild-centred, is made by converting an ingot of very mild cast steel, so that the additional carbon only penetrates a short distance. These bars are afterwards hammered or rolled down to the size required, and have the advantage of possessing a hard surface without losing the toughness of the mild centre.

Another special steel, somewhat analogous, is produced by melting a hard steel on to a slab of iron or very mild steel heated hot enough to weld with the molten steel, so that a bar may be produced, one side of which is iron and the other side steel, the quantity of each being regulated as may be required.

A kind of special steel, used for turning tools for chilled rolls and some other purposes, is made by adding a percentage of wolfram, or, as the metal is more generally called, tungsten, sometimes with and sometimes without carbon, sometimes to such an extent that it can be used without hardening in water. Special steel of this kind has the finest grain that can be produced, but it is so brittle that in the hands of any but

exceptionally skilled workmen it is useless. The addition of chromium, instead of wolfram, has somewhat the same effect.

Gold, silver and copper may be forged either when red-hot or cold, as soon as they have been purified from their earthy matters and fused into ingots; and the alloys of gold, silver and copper are also malleable either red-hot or cold. Fine or pure gold and silver are but little used alone; the alloy is, in many cases, introduced less with the view of depreciating their value than of adding to their hardness, tenacity and ductility. The processes which the most severely test these qualities, namely, drawing the finest wires and beating gold and silver leaf, are not performed with the pure metals, but gold is alloyed with copper for a red tint, with silver for a green, and with both for intermediate shades. Silver is alloyed with copper only, and when the quantity is small its colour suffers but slightly from the addition, although all its working qualities are greatly improved, pure silver being little used.

Lead and tin are malleable, flexible, ductile and inelastic whilst cold, but when their temperatures much exceed about half-way toward their melting heats, they are exceedingly brittle and tender, owing to their reduced cohesion.

Zinc, when cast in thin cakes, is somewhat brittle when cold, but when it is raised to about 300° Fahr. its toughness is so far increased that its manufacture into sheets by means of rollers is then admissible; it becomes malleable zinc, and retains the malleable and ductile character in a moderate degree, even when cold, but in bending rather thick plates it is advisable to warm them to avoid fracture. When zinc is remelted, it resumes its original crystalline condition.

An alloy is a combination by fusion of two or more metals. Metallic compounds containing mercury are *amalgams*. The

best-known, and perhaps the most generally useful alloy, is brass, which is formed by the fusion together of copper and zinc. Bronze made of copper and tin is a much more ancient alloy than brass, and has been known from remote antiquity.

All alloys are opaque, have a metallic lustre, are more or less elastic, ductile and malleable, and are good conductors of heat and electricity. Those consisting of metals of very different degrees of fusibility are usually malleable when cold and brittle when hot. Metals do not unite indifferently with each other, but have certain affinities. Alloys are generally harder and less ductile than the mean of their constituents, and their specific gravity is usually either greater or less than this mean. The melting-point of alloys is usually below that of either of the metals composing them: thus an alloy of eight parts bismuth, five lead and three tin, fuses at the heat of boiling water, that is 212° F.

Alloys very frequently possess more tenacity than their constituents would seem to indicate: thus an alloy of twelve parts lead and one zinc has double the tenacity of the latter metal and about six times that of lead. The malleability and ductility of alloys are in a great measure assignable to the degrees in which the metals of which they are respectively composed possess these characteristics.

A very slight modification of the components often produces a great change in the mechanical properties; brass, containing two or three per cent. of lead, is most readily turned, but works badly under the hammer, while that of the best quality for hammering is not turned with facility, owing to its toughness.

It appears to be scarcely possible to give precise general rules by which the properties of alloys may be safely inferred from those of their constituents; for although, in many cases, the working qualities and appearance of an alloy may be nearly a mean proportional between the nature and qualities of

the metals composing it, yet in other and frequent instances the deviations are excessive, as will be seen by several of the examples given in the following pages.

When lead, a soft and malleable metal, is combined with antimony, which is hard, brittle and crystalline, in the proportions of from twelve to fifty parts of lead to one of antimony, a flexible alloy is obtained, resembling lead, but somewhat harder, and which is rolled into sheets for sheathing ships. Six parts of lead and one of antimony are used for the large, soft, printers' types, which will bend slightly, but are considerably harder than the foregoing; and three parts of lead and one of antimony are employed for the smallest types, that are very hard and brittle, and will not bend at all; antimony, being the more expensive metal, is used in the smallest quantity that will suffice. The difference in specific gravity between lead and antimony constantly interferes, and unless the type metal is frequently stirred, the lead, from being the heavier metal, sinks to the bottom, and the antimony is disproportionately used from the surface. In the above examples, the differences arising from the proportions appear intelligible, as when the soft lead prevails, the mixture is much like the lead; and as the hard, brittle antimony is increased, the alloy becomes hardened and more brittle. With the proportion of four to one, the fracture is neither reluctant like that of lead, nor foliated like that of antimony, but assumes very nearly the grain and colour of some kinds of steel and cast iron.

The alloys of lead and tin partake of the general nature of these two metals; they are flexible when cold, even with certain additions of the brittle metals, antimony and bismuth, or of the fluid metal, mercury; but they crumble with a small increase of temperature, as these alloys melt at a lower degree than either of their components, to which circumstance we are indebted for the very fusible alloys. When the tin and lead

are alloyed, the former metal imparts to the mixture some of its hardness, whiteness and fusibility in proportion to its quantity, as seen in the various qualities of pewter, in which, however, copper, and sometimes zinc or antimony, are found. The same agreement is not always met with, as nine parts of copper, which is red, and one part of tin, which is white, both very malleable and ductile metals, make the tough, rigid metal used in brass ordnance, from which it obtains its modern name of gun-metal, but which admits neither of rolling nor of drawing into wire; the same alloy is described by Pliny as the soft bronze of his day. An increased addition of the tin, the softer metal, produces a gradual increase of hardness in the mixture; with about one-sixth of tin, the alloy assumes its maximum hardness consistent with its application to mechanical uses; with one-fourth to one-third tin, it becomes highly elastic and sonorous, and its brittleness rather than its hardness is greatly increased.

Zinc and lead will not combine without the assistance of arsenic, unless the lead is in very small quantity; the arsenic makes this and other alloys very brittle. Zinc and tin make, as may be supposed, somewhat hard and brittle alloys, but none of the zinc alloys, except that with copper, constituting brass, are much used.

With two parts copper and one part tin, the alloy is so hard as not to admit of being cut with steel tools, but it crumbles under their action; when struck with a hammer, or even suddenly warmed, it flies in pieces, and clearly shows a structure highly crystalline, instead of malleable. The alloy has no trace of the red colour of the copper, but it is quite white, susceptible of an exquisite polish, and, being little disposed to tarnish, it is most perfectly adapted to the reflecting speculums of telescopes and other instruments, for which purpose alone it is used.

Copper, when combined in the same proportions with a different metal, also light-coloured and fusible—namely, two parts of copper with one of zinc (which latter metal is of a bluish-white and crystalline, whereas tin is very ductile)—makes an alloy of entirely opposite character to the speculum metal, namely, the soft yellow brass, which becomes by hammering very elastic and ductile, and is very easily cut and filed.

Again, the same proportions—namely, two parts of copper and one of lead—make a common, inferior metal, called pot-metal, or cock-metal. This alloy is much softer than brass, and hardly possesses malleability; for example, when a beer-tap is driven into the cask, immediately after it has been scalded, the blow occasionally breaks it in pieces, from its reduced cohesion.

Another proof of the inferior attachment of the copper and lead exists in the fact that, if the moulds are opened before the castings are cooled almost enough to be handled, the lead will ooze out and appear on the surface in globules. This also occurs to a less extent in gun-metal, which should not on that account be too rapidly exposed to the air; or the tin *strikes to the surface*, as it is called, and makes it particularly hard at those parts, from the proportional increase of the tin. In casting large masses of gun-metal, it frequently happens that little hard lumps, consisting of nearly half tin, work up to the surface of the runners, or pouring places, during the time the metal is cooling.

In brass this separation scarcely happens, and these moulds may be opened whilst the castings are red-hot without such occurrence; from which it appears that the copper and zinc are in more perfect union than the alloys of copper with tin and with lead.

When dissimilar metals are combined, as the fusible lead, tin, or zinc, with the less fusible copper, gold, or silver, the

malleability of the alloys, when cold, is less than that of the superior metal, and when heated barely to redness they fall in pieces under the hammer; and therefore brass, gun-metal, etc. when red-hot, must be treated with caution and tenderness, Muntz's patent metal, which is a species of brass, and is rolled red-hot, appears rather a contradiction to this; but probably this alloy, like the ingots of cast steel, requires at first a very nice attention to the force applied. The action of rollers is also more regular than that of the hammer, and soon gives rise to the fibrous character, which in metals is the element of strength when it is uniformly distributed throughout their substance.

Annealing is a necessary process in the manufacture by drawing of wire and small tubing, and also in making brass, copper, or sheet-iron vessels by hammering and rolling; the metal, by compression, becoming hard and brittle, too much so for further reduction until annealed, after which it recovers its former softness and pliability.

CHAPTER II.

IRON AND ITS TREATMENT.

THE process of working iron and steel at the forge, as practised by blacksmiths, is designated forging—an art which consists in giving to iron every possible shape, either by beating out the article to be fashioned from a bar of metal, or by uniting various pieces of different shapes and sizes to form a composite mass of the required dimensions; the parts being joined together by "welding" at a heat very nearly approaching the melting-point of the metal operated on, thus forming a join equal in homogeneity to the solid metal. A few general principles of the art of forging will be of great service to most mechanics, as—though probably not, as a rule, equipped with a regular smithy, furnished with forge, anvil, and so forth—they are continually obliged to perform the process with more or less appropriate tools, and generally under disadvantageous circumstances; the kitchen fire sometimes serving for a forge, and not unfrequently a flat-iron has to do duty as an anvil.

The iron chosen for the work in hand should be proportionate in size and quality to the exigencies to which it has to be applied. If the object to be wrought can be made from a piece of plain bar iron, it will only be necessary to raise it to a white heat in the fire, then lay it on the anvil and beat into shape with a hammer till the iron becomes a dull red colour. The hammering may be continued till the metal becomes almost black, and by thus prolonging the operation the metal is made more homogeneous, the cracks are welded together, and the

metal made stronger and more close in texture. The method of making the article being forged will, of course, mainly depend on its shape ; but, suppose we wish to make a bolt of the shape usually called coach bolts, the following details will be interesting. The head of the bolt can be made by two methods—by "upsetting" and by "welding."

The first plan is to heat the extreme end of the rod to a good white heat, and then spread it by striking it on the end with a hammer, or, as is more frequently done, by holding the bar of iron itself in the hands and striking it, end on, on the anvil. This spreads the metal diameterwise, and will thus produce sufficient protuberance to make a head. If the end appears inclined to crack at all, the extreme point or end of the rod should be slightly cooled by immersing the end in cold water, or resting it for a short time against the face of the anvil ; this proceeding will make the end harder and less susceptible of cracking—in fact, the end itself will not be materially altered in shape, but will be driven bodily into the rod, which must of course expand sideways in a proportionate degree to the quantity of metal so driven in. It will be, of course, necessary to further shape the head to get a good square shoulder. For this purpose, the bolt blank has to be driven into a correspondingly-shaped hole made in a piece of flat iron. The end of the rod must be heated and the plain part of the bolt put through ; by blows on the head the blank is driven in till the head is flat against the hole in which the shank is. The hot metal is readily compressed to the form desired by using swages of any particular form. Should a mushroom-headed bolt be wanted, a swage with a corresponding hollow is placed against the red-hot bolt-head, and all the superfluous metal is driven through the plate, leaving only sufficient to fill completely the hollow in the swage. The hole in the plate would, of course, be square, so as to

produce the square shoulder requisite with mushroom-headed bolts, so as to prevent the bolt turning round when the nut is being screwed on and off.

The other plan of making a head or other protuberance is by welding on to the bar a separate piece of metal, which has first to be made into the form of a ferrule, the diameter of which must not, however, be so large as that of the iron bar to which it has to be welded. The sectional shape of the metal from which the ferrule has to be made is perfectly immaterial, though it should be as near as may be of the form intended for the finished article—pieces square, round, flat, oblong, semi-circular, &c., may be used for making the ferrules to be welded on; the substance of the added metal should be considerably more than the finished size of the bolt-head, as, though it may be reduced to almost any extent by hammering, it will be very difficult, if not impossible, to make the welded protuberance larger. When the ferrule is bent roughly into the shape required before being welded on to the main part of the bolt, it should not join as a perfect ring, but the two ends should gape slightly, and the ring being then put on the rod and the whole raised to a welding heat, on hammering the metal, the ring will be expanded and so close the crack mentioned.

In some cases, it is requisite to form a swelling on a bar of iron at some distance from its end, as, for instance, when making a spindle for a grindstone to run between staples; this swelling is made by heating the bar to nearly a white heat just at that part where the swelling should come, the metal on both sides being kept comparatively at a low heat, and then by striking the bar on the end the hot metal will yield and expand, forming a swelling.

To effect a proper weld, the iron, when heated to very nearly the required heat, must have sprinkled over it, at the

points of contact, a little silver sand. The metal is then put back into the forge fire, and the heat raised to welding point, the sand melting and forming a vitreous covering, which preserves the iron from the effects of the sulphurous fumes escaping from the coal, and also prevents the ashes of the fire from adhering to the metal, in which case, on the application of the hammer, they would become embedded in the iron, and so spoil its texture. The glassy covering also prevents the oxidising and scaling action of the fire.

Some of the errors in forging are over-heating, over-working and lack of proportionate heating and working. In a welding state, fibrous wrought iron approaches the state of fusion without reaching it. In the cupola, the object is to drive the iron to a fluid state as rapidly as possible, and the piece of pig iron in the cupola melts and runs from the outside while its central core is only at a red heat. Such uneven heating will not do for the weld; the iron must be evenly heated all through, and not be merely at a white heat outside. A "soaking heat" is necessary for a weld, and this is why sand is thrown over the iron while at a white heat; the sand is not a flux: it forms a protection, allowing the interior of the iron to be heated, while protecting the outside from burning and defending it from cooling.

There must be no hurry about heating for a weld; there must be no forcing of the bellows or blower blast; a steady, quiet, roasting heat is necessary. But the weld itself must be quick work, but not too much of it. In this latter part of the work is the most frequent error. The edges of the weld are sometimes hammered down until almost cold, and every blow given after the weld heat is gone drives some scale into the iron to weaken the weld. This is the fault in those cases where a weld is discovered in after use by torsion or tension. A good weld will never show its line of junction by weakness.

But a weld that is forced after the first stage of cooling, although it may "stick" for a time, will not last when put to a working strain.

In joining together bars of iron, end to end—as is necessary, supposing a piece cannot be found sufficiently long for the purpose required—these particulars must be borne in mind:— The ends to be joined together by welding should, in the first place, be slightly "upset," which is the technical way of expressing the operation of spreading the iron diameterwise, by heating the end and striking the bar in the direction of its length, much in the same way as a cold chisel is struck when in use; this will cause the ends to be somewhat larger than the original diameter of the rod; the faces of the ends are then beat off by the hammer to form a scarf joint, and the two pieces are made hot in the forge fire. On their attaining a welding heat, the two pieces are laid together and a weld effected by light blows with the hammer, and as soon as the two are found to be really joined, that part is put in the fire and re-heated to white heat, the join being completed by hammering. If the operation has been carried out properly, the welded joint may be so neatly done that it is only by very critical examination that it can be detected at all.

Ordinarily less care is taken of the "jump weld" in progress than the "scarf weld," although, from the less amount of welding surface exposed, it would be considered that to be more careful was an absolute necessity. In the "jump weld," or the "butt weld," as it is indifferently called, the two ends of the bars to be united are upset by heating and hammering against them to produce a swell sufficient to allow for the burning and scaling of the heat and hammering, and the two end faces of the bars, after proper heating, are brought together and fastened by a few light taps on the other ends of the bars. This fastening is enough for one heat; the united bar

should be immediately returned to the fire and reheated before the joint is hammered down to size. The reason is that all the outside of the upset is comparatively cool when the central portion of the bars are "stuck," and should be again heated to the welding heat before being hammered on the outer portions. There are smiths who boast of being able to make a butt weld on a two-inch bar at a single heat; circumstances must be favourable when this can be done.

Iron is always subject to fractures lengthways of the metal. These are caused by the non-adhesion of the particles through the intervention of some foreign matter, usually in the early stages of manufacture. By constant forging, these flaws may be very greatly reduced in magnitude; and "faggoted iron" is the best which is to be obtained for tenacity. Lathe mandrels are made of faggots of iron, with steel collars welded on for the bearings. The method of making these faggots is to take a quantity of small pieces of iron of good quality, and generally square section, and gradually to weld these into a thick cylindrical piece.

Suppose three pieces of $\frac{1}{4}$-inch square iron were welded together into a solid bar, twisting each piece separately, and the whole together, so that the molecular formation of the complete bar will be as equal as possible, it will be understood that such a bar will be far more trustworthy as a whole than would be either of its component pieces taken at a proportionate value. If three such compound bars were then welded together, still twisting each as before, the homogeneousness of the bar would be still further improved; and by again repeating the process, and thus welding twenty-seven distinct bars into a solid mass, the texture of this will be far more uniform and good than could be obtained in iron produced in the usual way of making rolled bars. The method here given is, as above stated, largely adopted for making lathe mandrels, and

the iron mandrels so produced are better than those made of cast steel for standing the knocking about to which a lathe is generally subjected in an engineer's shop.

Iron may have a steel-like surface imparted to it by the process known as case-hardening. After going through the process, the iron articles may often serve the purpose of steel.

Steel articles which require to be hardened are wrought to their proper form and filed to shape when the metal is in its softest state, and the finished article is then hardened, as described in Chapter III., and can be rendered bright and polished by the application of emery in some form. This peculiar quality of hardening is dependent on the amount of carburisation of the steel, and the mechanician has availed himself of this knowledge to produce on iron a surface of steel which is capable of being hardened by the same process as though the article were of solid steel, though in this case the hard part is only skin deep. It is the absence of a necessary proportion of carbon in wrought iron that renders it unsusceptible of hardening, and the deficiency of carbon is supplied to the surface of the iron by heating it to redness in close contact with leather, bones, or other animal refuse rich in the required element. Chemicals have been employed to produce the same effect, and prussiate of potash or ferrocyanide of potassium, plentifully applied to the red-hot iron, will answer equally well. The heat decomposes the prussiate of potash, and the liberated carbon combining with the iron forms a coat of steel upon the surface.

The latter materials are those most commonly used for small articles which may be wanted in a hurry; and the process of case-hardening simply consists in heating the iron to redness, sprinkling its surface plentifully with one of the above chemicals, then returning it to the fire to allow the car-

burisation to take effect and to get the now steel to a hardening heat, and, on being suddenly cooled, the article will be hard as steel. The thickness of the hardened coating will be very slight. If a greater thickness be desired, this process must be repeated.

By the process of case-hardening, any articles, if of good iron, can be hardened to equal steel, but the hardening only penetrates skin deep. There is no occasion to temper the iron at all after case-hardening, and any parts of the objects can be rendered hard, leaving the other parts in their normal condition. An ordinary fire will furnish all the heat requisite. In the first place, provide sufficient of the hardening compound, made as follows :—Take equal parts of prussiate of potash, sal ammoniac and common salt; pulverise and thoroughly mix. The process of case-hardening is then conducted as follows :—First make the iron hot, and spread the compound over that part to be made hard; again put the iron in the fire and fuse the powder, allowing it to run all over the parts to be operated on. Up to this stage the metal should only be heated to a moderate extent, say, just bordering on red heat; the compound may be applied several times; the more put on, to a certain extent, the deeper will be the hardening; this is a detail which practice alone will enable one to determine. Having thoroughly melted a quantity of the powder, and allowed it to soak in at a dull red heat, raise the temperature to that required for hardening steel, a full blood red, and quench the article in cold water. The surface which has been operated on by the hardening powder will now be as hard as hardened steel, whilst that part which has not had any powder applied to it will be as soft as ever. This is the most simple process, and will be found very easy to perform. Prussiate of potash alone will effect the hardening, but the compound is better. A little practice will enable one to

estimate the exact quantity of powder requisite to produce the desired effect.

Case-hardening, when carried out on a more extensive scale, is effected by enclosing the articles to be case-hardened in wrought-iron boxes, together with animal refuse, such as above enumerated, and subjecting the whole to a continuous red heat, for a period of from twelve hours, extending in some cases to several days. At the end of that time—the carburisation having been effected—the articles are hardened by making red hot and suddenly cooling.

Exposing the iron to a red heat, for some hours, surrounded by leather cuttings or the parings of hoofs and horns, the whole being placed in a metal box of some kind, will likewise make the surface of the iron susceptible of being hardened on being cooled in cold water when at a red heat. The usual method of carrying out this last process as follows :—

Get a sheet-iron box, according in size to the quantity and size of the objects to be hardened, pulverise a sufficient quantity of bones into dust, and pack the iron in the bone-dust. Place the box, when packed with objects and dust, in the fire of an ordinary smithy, and gradually get the whole to a cherry-red heat throughout. When all is of an uniform heat, plunge into cold water, and the iron will receive a coating of steel from the carbon of the bones. This latter process is comparatively so long and tedious that it is scarcely likely to be employed on an emergency in preference to the one first described. However, the second finds favour amongst large manufacturers, and is said to be more efficacious in producing a deeper and more uniform hardened skin. For the purposes required in miscellaneous work, the prussiate of potash answers equally well, and few amateurs would care to spend hours—from six to twenty-four—in giving the furnace and contents the requisite attention whilst carrying out the animal refuse process,

An operation, having for its object an exactly opposite effect, is carried out in producing malleable cast iron, so termed from its being rendered somewhat malleable. The object of this process is to remove from the cast iron the excess of carbon, and so render it similar to soft steel or malleable iron; and the object is effected by placing a decarbonising material in contact with the casting, for which powdered peroxides of iron are generally used, and the heat kept up for from three to six days. Such so-called malleable iron cannot be worked when heated, though it may be hammered to a certain extent when cold.

CHAPTER III.

STEEL AND ITS TREATMENT.

ALTHOUGH the characteristic property of steel, upon which its usefulness mainly depends, consists in its capacity for hardening, the oft repeated question, Why does steel harden? has never been satisfactorily answered. Until it is fully answered, all the different methods of hardening must necessarily partake more or less of the nature of experiments.

If we heat a piece of cast steel to redness and plunge it into clean water until its temperature is reduced to that of the water, the result will be that the steel will be hardened. The degree of the hardness will depend upon the quality of the steel, the temperature to which it was heated, and to a small degree upon the temperature of the water in which it was cooled. In any event, the operation will be termed that of hardening. If we reheat the steel a softening process will accompany the increasing temperature, until upon becoming again red hot it will assume its normal softness, and if allowed to cool in the atmosphere the effects of the first hardening will be entirely removed.

It is generally accepted that by heating and cooling steel in different degrees and at different rates of rapidity we may not only obtain a great difference between extremes of hardness and softness, but also almost any intermediate degree of hardness and softness between these extremes. Recent investigations have demonstrated the fact that, apart from its chemical composition, the tempering quality of steel is also

largely influenced by the degree of heat at which it is tempered, and also by the temperature, the conductivity and the capacity for heat, and the boiling point of the cooling liquid. And since the degree of the first hardening depended upon the quality of the steel, the degree to which it was heated and the temperature of the water in which it was cooled, it follows that the quality of the steel, as well as heating and temperature, must be uniform in all cases if uniform results are to be reached.

The higher the grade of steel, the lower the temperature at which it will harden, and the harder it will be if cooled in water from a given temperature.

The soft steels, approaching more in their nature to wrought iron, are exceedingly difficult to harden and temper to a uniform degree, because of the difficulty experienced in producing them of uniform grade. Many kinds of these steels are made of so low a grade as to make it difficult to determine the line of demarcation separating them from wrought iron.

While the capacity of steel to cut is mainly due to the temper, the durability of the cutting edge is determined by the quality of the steel and its adaptability to the kind of work upon which it is employed. For cutting tools, the best of cast steel is employed. The degree of temper is varied to accommodate the nature of the duty. The cost of steel of which a tool is made is of very little importance compared to its efficiency, because this cost is very little in comparison with that of performing the duty. For example, a steel turning-tool weighing but two or three pounds will cut off many thousand pounds of iron, the operation lasting perhaps several weeks. The speed at which this tool will cut—or, in other words, the time it will take to cut off a given amount of iron—will vary 30 or 40 per cent. from a very slight difference in the quality of the steel of which the tool is made. The cost

of the operator's time is so much greater than that of the steel used up in a given time as to render it, even in the case of cheap labour, always economical to employ the best of steel. With a given quality, however, the efficiency depends upon the skill employed in the forging, hardening and tempering of the tool, as well as upon its shape.

A practice sometimes prevails of withdrawing the steel from the water before it is quite cold, and many excellent hardeners and temperers withdraw the steel from the water when it has sufficient heat left in it to rapidly dry off the water adhering to it, the result being, it is claimed, to alter the degree of hardness to a practically imperceptible degree, but to add considerably to the strength of the hardened steel. To the skilful performance of these operations we must look for the difference in the quantity of work performed by different workmen, even when using the same grade of steel for similar duty.

When steel arrives in the user's hands, the first process which it undergoes is forging it into the shape required. This is really two processes—first, that of heating it to make it malleable; and second, that of hammering it, while it is hot, into the required shape. The golden rule in forging steel is to heat it as little as possible before it is forged, and to hammer it as much as possible in the process of forging. It is impossible to lay down exact rules for each of the thousands of tools for which steel is used. The treatment of each tool in each process which it undergoes is an art that can be learnt only by practice. The worst fault that can be committed is to overheat the steel. When steel is heated it becomes cross-grained; its silky texture is lost. To account for this change, we must fall back upon the mysterious and unknown laws of crystallisation. The fact remains that the fine grain has become coarse, and can only be restored by hammering or sudden cooling. If the temperature be raised above a certain point

the steel becomes what is technically called "burnt," and the amount of hammering which it would require to restore its fine grain would reduce it to a size too small for the required tool, and the steel must be condemned as spoilt. Overheating the fire is the primary cause of cracking in the water; the percentage of phosphorus in it may be so high that the amount of heat absolutely necessary to forge it at all into the shape required may cause it to crack in hardening.

In heating steel to harden it there arise many considerations, the principal of which are as follows:—The size of an article will often be an important element for consideration in heating it, because, by heating steel in the open fire, it becomes decarbonised; and it follows that, the smaller the article in sectional area, the more rapidly this decarbonisation takes place. In large bodies of metal the decarbonisation due to a single heating is not sufficient to have much practical significance; but if a tool requires frequent renewal by forging, the constant re-heating will seriously impair its value, and, in any event, it is an advantage to maintain the quality of the steel at i s maximum. To prevent decarbonisation for ordinary work, charcoal, instead of coal, is sometimes used; and where hardening is not done continuously, it is a good practice; because a few pieces of charcoal can be thrown upon the fire and be ready for use at a few minutes' notice. Charcoal should be used for the heating for the forging as well as for that for the hardening. Green coal should never be used for heating the steel for the hardening, even if it is for the forging process, because, while the steel is being well forged its quality is maintained, but afterwards the deterioration due to heating is much more rapid.

A coke suitable for heating to harden should be made and always kept on hand. To obtain such a coke, make a large

fire of small soft coal, well wetted and banked up upon the fire, and, with a round bar, make holes for the blast to come through. When the gas is burnt out of the interior coal, and the outside is well caked, it may be broken up with a bar, so that the gas may be burned out of the outside, and then the blast may be stopped and the coke placed away ready for useat a moment's notice. Good toolsmiths always keep a store of this coke for use in taking welding heats, as well as for hardening processes. It is desirable that the article be heated as quickly as possible, so as to avoid decarbonisation as much as possible. If an article has a very weak part, it is necessary to avoid resting that part upon the coal or charcoal of the fire, otherwise the weight may bend it; and in heating long slender pieces, they should bend evenly in the fire or furnace, or, when red hot, the unsupported parts will sag. In taking such pieces from the fire the object is to lift the edges vertically, so that the lifting shall not bend them; and this requires considerable skill, because it must be done quickly, or parts will get cooled and will warp, as well as not harden so much as the hotter parts.

The part of the tool required to be hardened must be heated through, and heated evenly, but must on no account be overheated. Our tool must be finished by sudden cooling, and if this does not give to the steel a fine grain and silky texture—if, after the cooling, the fracture, were it broken in the hardened part, should show a coarse grain and dull colour, instead of a fine grain and glossy lustre—our tool is spoiled. The special dangers to be avoided in hardening each kind of tool must be learned by experience. Some tools will warp if they are not plunged into the water in a certain way. Tools of one shape must cut the water like a knife, those of another shape must stab it like a dagger. Some tools are hardened in a saturated solution of salt, the older

the better, whilst others are best hardened under a stream of running water. Most tools have a tendency to water-crack if taken out of the water before they are absolutely cold. Where the edge of a tool only is hardened, care should be taken to move it up and down in the water, so as continually to change the water-level, lest the tool should crack at the water-level. Steel expands as it becomes heated; if one part becomes hotter than another it expands more, and the form of the steel changes to accommodate this local expansion, and this alteration of shape becomes permanent. In finished work this is of very great consideration, and, in the case of tools, often entirely destroys their value. If an article has unequal thicknesses it requires to be manipulated in the fire, so that the thin part shall not become heated in advance of the thicker body of the metal, or it will become distorted or warped; because the more solid parts are too strong to give way to permit the expansion, and the latter is accommodated by changing to the form of the weakest part of the article. The part having the smallest sectional area is not necessarily the weakest when in the fire, unless it is as hot as the rest of the body.

The necessity of heating an article according to its shape thus becomes apparent, and the aim should be to heat the article evenly all over, taking care especially that the thin parts shall not get hot first. If the steel is heated in the open fire, it may be necessary to take it from the fire occasionally and cool it, and to so hold it in the fire that the thin part is least exposed to the heat. If the article is large enough, the thin parts may be protected by wet ashes during the first part of the heating. If the article is of equal thickness all over, it is necessary to so turn it in the fire as to heat it uniformly all over. In every case, care should be taken not to heat the steel quickly. The heating, whether done in the open fire or in a heating bath, must be done uniformly, so it

may often be necessary to hold the article, for a time, with only the thick part in the heating material; in this case it should not be held quite still, but raised and lowered gradually and continuously, to ensure even heating.

One of the principal reasons why a high-class quality of steel is required for certain purposes is that it will suffer less injury by being heated to a greater degree, or by being heated and reheated a greater number of times, than inferior qualities of steel. In heating steel, the happy medium must be attained between heating it too much and too little, and between letting it lie too long "soaking" in the fire, and not "soaking" it through. Both the degree of temperature and the duration of the heat must be carefully watched.

Some tools, such as circular cutters, files, etc., after they are forged into the shape required, must have teeth cut into them. Before this can be successfully accomplished a preliminary process is necessary. Hammering or forging the steel into the shape required will have hardened the steel to such an extent as to make the cutting of teeth into it impossible or difficult; it must consequently be annealed. This process is a double process. The steel must be reheated as carefully as before, and afterwards cooled as slowly as possible. Many tools are only required to be hardened on a small part of their surface, and it is important that the unhardened parts should possess the maximum amount of toughness, with the minimum amount of brittleness that can be attained. These tools must also be annealed after they are forged. The process of annealing, or slow cooling, leaves the steel cross-grained, gives it its maximum of ductility, and causes it, in fact, to approach the properties of lead.

In softening steel, the first consideration is the purpose of the operation. If it is merely intended to draw the temper of an over-hardened piece of steel, its ultimate use will entirely

decide the question. Uniform and careful heating, and good judgment, acquired by intelligent practice, are the only safe guides. If, on the other hand, annealing for the purpose of restoration of ductility is intended, then the treatment the material has received, and the heat at which it was last worked, become most important considerations. Specific rules applicable to all cases cannot possibly be laid down, and the experience and good judgment of the steel worker must be relied upon.

The general rules governing annealing may be summed up as follows: Heat slowly and uniformly the entire piece to a temperature higher than that at which the metal was last worked—if hammered or straightened cold, to a bright red. Allow cooling to take place as slowly as possible and excluding the air. If the steel has not been heated above dark cherry red and is low in carbon, annealing in boiling water will give excellent results.

The surface of steel may be hardened by the aid of a powder composed of bichromate of potash, 6 oz.; prussiate of potash, 6 oz.; chloride of sodium, 22 oz.; all to be finely pulverised and to be thoroughly mixed. Heat the steel to a dull red, cover with a thick coating of the powder, heat again to cherry red, and plunge in cold water. Fine steel, as well as iron, may be case-hardened with this powder if not made too hot; a few trials will determine the difference in the heat to use to thoroughly harden through, or merely case-harden. A strong solution of this powder will give a harder temper than common water.

We now come to the cooling or quenching, which requires as much skill as the heating to prevent warping and cracking, and to straighten the article as much as possible during the cooling process. As to the influence of the cooling liquid upon the tempering of the steel, there is yet a large field of

inquiry still open. It is a fact that the temperature of the cooling liquid in itself furnishes no criterion of the hardness to be obtained. Steel may be hardened not only in cold water, but also in boiling water, boiling oil, melted lead, tin or zinc. Considering that steel loses a great deal of its hardness—"that the temper is drawn"—by heating it to about 600° F., it seems paradoxical to assert that cooling it in a metal bath of 750° to 800° F. would harden it. Yet steel wire will harden in passing through a bath of melted zinc, and lose its temper again if allowed to remain for a long time in the same bath. Knowing that hardening and tempering is accompanied by a change of the internal structure of steel, and that such change cannot take place at a lower temperature than 900° F., we must conclude that the hardening of steel depends chiefly on the rapidity with which it is cooled from a temperature of about 950° F. to one below 950° F.—or, in other words, the rapidity with which its red heat is destroyed. The softening of steel, or drawing of the temper, is due to exposure to temperature below the above limits. The tempering of steel can no longer be admitted to be alone dependent on the temperature or conductivity of the cooling liquid. In fact, fused metals possess remarkable power of hardening.

The hardening power does not depend merely on the temperature and conductivity of the cooling fluid, but also on its capacity for heat and the height of its boiling point. It follows that the great hardening power of water must be attributed to its production of vapour rather than its conductivity. This becomes evident when it is remembered that water in in contact with metal at a temperature of from 900° to 950° F. cannot, under ordinary pressure, remain in a liquid state, but must be rapidly converted into steam. Therefore, the heated steel remains enveloped by a film of steam until cooled. The formation of steam renders much heat latent,

thereby assisting the hardening process. Rapid motion of the steel greatly aids hardening under water : therefore we must further conclude that steel will be all the better hardened the more rapidly the steam formed is drawn away. With a view of accomplishing this, hardening under a running stream of water and hardening with a spray have been successfully employed, and have given better results as to degree of hardness and uniformity than the ordinary method of hardening under water. For tempering small articles, melted metal baths, especially tin, give the best results for uniformity of hardness, and since the certainty of the temperature of the bath is an important factor in the process, their use commends them to very favourable consideration.

Steel contracts in hardening, and contracts most where it is cooled most suddenly. If the hardened part join on to the unhardened part too suddenly, the steel at the junction will be in a dangerous state of tension which disposes it to crack, and it is wise to lessen the amount of tension by distributing it over as great an area as possible. In some tools, where the shape necessitates a great difference in the rapidity of cooling, it is wise to drill holes in the thicker parts where they will not interfere with the use of the tool—holes made neither for use nor ornament, but solely with a view of equalising the rapidity of the cooling of the various parts, so as to distribute the area of tension, and thus lessen the risk of cracking in hardening. The cooling should be performed with a view to prevent the contraction of the metal from warping the weaker parts; and to aid this those parts are sometimes made a little hotter than the more solid parts of the article, the extra heat required to be extracted compensating in some degree for the diminution of sectional area from which the heat must be extracted. Water, for cooling, must be kept clean, and in that case it becomes better from use. It may be kept heated to

about 100° F., which will diminish the risk of having the article crack. Cracking occurs from the weaker parts having to give way to suit the contraction of other parts, and usually takes place in the sharp corners of the articles, or through the weakest section; in articles found to be liable to crack, such corners are made as rounded as possible. If the water is very cold, and the heat is extracted very rapidly from the outside, the liability to crack is increased, and in many cases the water is heated to nearly the boiling point, so as to retard the extraction of the heat. The hardening of the steel is due to the rapid extraction of its heat; increasing the temperature of the water diminishes the hardness of the steel; and it is necessary to counteract this effect as far as possible, which is done by adding salt to the water, the steel hardening more thoroughly in the saline mixture.

Hardening in oil is another mode of treating steel, which appears, to a certain extent, to attain by one process the change from lead into whalebone without passing through the intermediate glass stage, and is of great value for certain tools.

All articles that are straight or of the proper form when leaving the fire should be dipped vertically, and lowered steadily into the water; and if of weak section, or liable to crack or warp, they should be held, quite still, low down in the water until cooled quite through to the temperature of the water. If the article is taken from the water too soon, it will crack; and this is a common occurrence, the cracking often being accompanied by a sharp audible "click." Pieces of blade form should be dipped edgeways, the length of the article lying horizontally and the article lowered vertically and held quite still, because, by moving it laterally, the advancing side becomes cooled the quickest, and warping and cracking may ensue. Straight cylindrical pieces are dipped endwise

and vertically. When, however, the dipping process is performed with a view to leave sufficient heat in the body of the article to lower or temper the part dipped, the method of procedure is slightly varied.

So many causes may produce water-cracks, that it is often difficult to point out the precise cause in any given case. Perhaps the most common cause is overheating the steel in one or more of the processes which it passes through in the consumers' hands, or it may have been overheated in the process of forging, or rolling it into the dimensions required whilst in the hands of the manufacturer. A second cause may be found in the overmelting or too long boiling of the steel, causing it to part with too much of its occluded carbonic acid—a fault which may be attributed to the anxiety of the manufacturer to escape honeycombs in the ingot. A third cause may be sometimes discovered in the addition of too much manganese, added with the same motive. A fourth cause may curiously enough prove to be a deficiency of carbon, whilst in some cases too much will produce the same effect. A fifth cause may be the presence of too much phosphorus in the steel; but, after all, this may not be the fault of a greedy manufacturer who wants to make too great a percentage of profit: it might be the fault of a stingy consumer, who begrudges the cost of good steel, yet there is nothing more dear than cheap steel. It must be more economical to put five shillings' worth of labour upon steel that costs a shilling, to produce a tool that lasts a day, than to put the same value of labour upon steel that costs only ninepence, to produce a tool that only lasts half a day.

Tempering, when performed by a second operation, reducing the hardness obtained by a previous one, is dependent for its uniformity upon the uniformity of the first one. If a number of pieces of steel, of the same quality, be heated to an equal

temperature and plunged in water until cooled, and are subsequently tempered to the same shade of colour, they will all possess an equal degree of hardness; but if other pieces of steel of a different quality (this may be further specified by saying "containing a different percentage of carbon") be subjected to precisely the same processes, leaving upon them the same temper colour, though this latter batch will be uniform in hardness, it will not possess the same degree of hardness as the pieces of the first batch; temper colour may be used as proof of equality in the degree of temper in pieces of the same steel, but is not indicative of any determinate and uniform degree of hardness.

Since the introduction of methods of hardening and tempering, above referred to, the terms hardening and tempering have come to be used by many persons indiscriminately, and it is a fairly debatable question what process should be termed hardening and what tempering. Any degree of hardness less than that obtainable in a given quality of steel, heated to the brightest degree without causing the chemical change known to smiths as "burning the steel" to set in, must be a degree of temper, because it is a degree of hardness less than the maximum, notwithstanding that it would have no representative colour under the colour test.

A piece of hardened steel heated slightly, and allowed to cool again, becomes tempered. It suddenly changes from brittle glass to supple whalebone, and in the process of changing its nature, fortunately it changes colour, so that the workman can judge by the hue of the colour the extent of the elasticity which it has acquired, and can give to each tool the particular degree of temper which is most adapted to its special purpose. After the steel is hardened, if we polish one of its surfaces and slowly reheat it, that surface will assume various tints, beginning with a pale yellow and ending in a blue with a green tinge, each

colour appearing as the steel attains a definite temperature. By the appearance of the colours we are informed of the temperature of the steel, or in other words, how far, or to what extent the resoftening has progressed. This is taken advantage of by the machinist to obtain steel of any required degree of hardness less than that of the absolute hardness obtained by hardening, and is termed tempering. The temperatures at which these respective colours will appear are as follows:

	Fahr.
Very pale yellow	430°
Straw yellow	460°
Brown yellow	500°
Light purple	530°
Dark purple	550°
Clear blue	570°
Pale blue	610°
Blue tinged with green	630°

The various colours through which tempered steel successively passes are straw, gold, chocolate, purple, violet and blue. Of course, in passing from one colour to another, the steel passes through the intermediate tints. It really passes through an infinite series of colours, of which the six above-mentioned are arbitrarily selected as convenient stages. The elasticity of tempered steel is acquired at the expense of its hardness. It is supposed that the maximum of hardness and elasticity combined is obtained by tempering down to a straw colour.

To say that a piece of steel has been tempered to a straw colour implies that it was first hardened and then re-heated until the straw yellow appeared upon it, the temperature having arrived at 460° F., and that the reheating process was then discontinued. The presence of the straw colour, however, while evidence of temperature to which the heating took place, is no indication of the actual degree of hardness

of the steel, because that depends upon the degree to which the steel was hardened before the colour-test tempering was resorted to.

The presence of a colour obtained on a piece of steel by subjecting it to heat is therefore no evidence that the steel possesses any above its normal hardness, for steel; wrought iron, and cast iron that has been softened to the lowest degree, will show all the colours on a polished surface, providing that the metals are heated to the necessary temperature; thus the presence of colour is simply a proof that the steel has been heated to a certain temperature, but by no means proof that it possesses hardness, or indeed that the process of heating has in any way modified its hardness or softness, but any degree of hardness obtained from a temperature equal or less than the highest at which a colour would appear—that is 430° F.—will obviously be representable under the colour process by a colour, providing of course, that the steel was first thoroughly hardened.

It is well to adopt a tempering process that will determine with approximate accuracy the first heating temperature, such as by heating the article in some flux, as melted lead, melted salt, or melted glass, plunging it into a cooling mixture or liquid whose temperature can be maintained, by suitable means, somewhat equable, and drawing the temper in a bath maintained at the thermometrical temperature. By these means, the steel used being a brand of known uniformity, both the hardening and the tempering will give the greatest practically obtainable degree of temper, and the tools will be hardened more suitably to the requirements of the duty than is obtainable under the colour test. This plan is largely resorted to when large numbers of pieces require tempering, but if the articles are large, or when tempering requires to be done piecemeal and at odd times, it will not pay, as a rule, to keep heating

and tempering mixtures constantly ready upon the fire, and the open fire and colour gauge must be resorted to. The whole of the skill of the hardener and temperer is called into play under these latter conditions from the moment the steel is placed in the fire until it is cooled to the temperature of the water.

It is desirable to obtain any degree of hardness by a single process if possible. In some cases, by heating a known quality of steel to a definite temperature, and quenching it in liquid maintained at about an even temperature, the colour is becoming dispensed with, the conditions of heating and cooling being varied to give any degree of hardness. Another and a very desirable method of hardening and tempering is to heat in a flue of some kind maintained at the required temperature over the fire, and after quenching, instead of applying the colour test, provide a tempering bath composed of some substance heated to a temperature of from 430° to 630°. By placing the articles (after hardening them) in the tempering bath and heating it to a temperature equal to the colour of the temper required, we have but to cease heating the tempering bath when a thermometer marks the required temperature. A uniform degree of temper will be given to all the articles, and the operation will occupy much less time than would tempering by the colour test, because a liquid is much more easily kept at an equal temperature throughout its mass than are the heated sand, or hot pieces of metal, resorted to in tempering by the colour test. Another method of tempering is to heat the steel to a definite temperature, and cool or quench it in a liquid having sufficient greasiness or other quality which acts to retard its retraction of the heat from the steel, and thus give a temper at one operation. As an example of this kind of tempering, it is said that milk and water, mixed in proportions determined by experiment upon

the steel for which it was employed, has been found to give an excellent spring temper. Such tempering carefully conducted may be of the very best quality. A great deal, however, in this case depends upon the judgment of the operator; because very little variation in heating the steel or in the proportions of milk to water produces a wide variation in the degree of temper. If, on trial, the temper is too soft, the steel may be made hotter, or more water added to the milk. If the steel was heated as hot as practicable without increasing the danger of burning it, more water must be added, while if the steel was made red hot without being hot enough to cause the formation of clearly perceptible scale, the steel may be heated more. It is desirable, in all cases, but especially with a high quality of steel, not to heat it above a blood red heat, although sheer and spring steels may be, and often must be made hotter, in order to cause them to harden when quenched in water.

Hardening and tempering steel, as applied to cutting tools, are much more simple than when the same operations are required to give steel elasticity as well as durability of form, or to give durability to pieces of slight and irregular form of sufficient hardness to withstand abrasion. One reason of this is that for tools a special and uniform quality of steel is readily obtainable, which is known as tool steel. Special sizes and grades are made to suit the manufacture of any of the ordinary forms of tools. The materials purchased under the name of steel, whether crucible or otherwise, may vary so much as to seriously affect the degree of hardness or temper obtained by any specific process, even though of the same make and brand. Most difficulties are in obtaining a uniform degree of temper or in tempering without loss from water-cracks, &c. These defects may be overcome by varying the method to suit the quality of the steel.

This is not so much due to superior quality of the steel as to a precise knowledge of the processes necessary to temper such steel to the best advantage. We have no known method of practically ascertaining in the workshop the quality of a piece of steel unless it be by use. If we give a mechanic a piece of steel soft at one end and hard at the other end, the graduation proceeding uniformly from end to end, he can take a file and, after testing the hardness, mark upon the steel with tolerable accuracy the portions corresponding in hardness to a blue, a purple, a brown, and a straw colour, and he would know of what hardness to make a tool that would cut the steel at any particular section not too hard to entirely resist cutting. This knowledge is obtained from manipulations performed upon steel of all degrees of colour temper, but if we were to give him a piece of steel harder than any degree denoted by a colour, yet not of maximum hardness, he would be dealing with an utterly unknown quantity.

As a rule, the steel that shows a fracture of fine dull grain, the face of the fracture being comparatively level, is of better quality than that showing a coarse or granulated surface, brightness denoting hardness, and fibrousness, toughness.

Very few steels are as yet sufficiently uniform to render it practicable to employ an unchangeable method of tempering, and to this fact is largely due the use of particular brands of steel.

In tempering steel, regard must be had to the quality most essential in the special tool to be tempered. A turning tool is required to be very hard, and is often taken out of the water hot enough to temper itself down to a degree so slight that no colour is perceptible, whilst a spring is required to be very elastic, and may be tempered down to a blue.

A scientific explanation of the process of tempering steel has yet to be given, without mystifying one by talking unintelligibly about molecular re-arrangement and crystalline transformations.

CHAPTER IV.

BRASS AND ITS TREATMENT.

BRASS, as previously stated, is perhaps the best known and most generally useful alloy. It is formed by fusing together copper and zinc: different proportions of these metals produce brasses possessing very marked distinctive properties. The table on page 46 gives the composition of most useful alloys allied to brass. The proportions of the different ingredients are seldom precisely alike; these depend upon the requirements of various uses for which the alloys are intended. Peculiar qualities of the constituent metals also exercise considerable influence on the results—as has been mentioned on the first page.

Brass is fabled to have been first accidentally formed at the burning of Corinth 146 B.C.; but articles of brass have been discovered in the Egyptian tombs, which prove it to have had a much greater antiquity. Brass was known to the ancients as a more valuable kind of copper. The yellow colour was considered a natural quality, and was not supposed to indicate an alloy. Certain mines were much valued, as they yielded this gold-coloured copper, but after a time it was found that by melting copper with a certain earth (calamine), the copper was changed in colour. The nature of the change was still unsuspected.

Alloys of copper and zinc retain their malleability and ductility when the zinc is not above 33 to 40 per cent. of the alloy. When the zinc is in excess of this a crystalline character begins to prevail. An alloy of one copper to two zinc may be crumbled in a mortar when cold.

Yellow brass, that files and turns well, may consist of copper 4, zinc 1 to 2. A greater proportion of zinc makes it harder and less tractable; with less zinc it is more tenacious, and hangs to the file like copper. Yellow brass (copper 2, zinc 1) is hardened by the addition of two to three per cent. of tin, or made more malleable by the same proportion of lead.

There would be less diversity in the results of brass castings if what was put into a crucible came out of it. The volatility of some metals, and the varied melting points of others in the same mix, greatly interfere with uniformity in ordinary work. Zinc sublimes (burns away) at 773 to 800 degrees, while the melting heat of the copper with which it should be intimately mixed in making brass—is nearly 1,750 degrees. Copper, zinc, tin and lead in varying proportions form alloys, always in definite quantity for a given alloy. The ease with which some of the metals are burned away at comparatively low temperatures renders it a very easy matter to make several different kinds of metal with the same mix. This very thing occurs, and the great difficulty in getting bearing brasses uniform in quality causes some engineers to babbitt all bearings as the best way to ensure uniformity. One lot of castings may be soft and tough, another hard, and so on.

Zinc is added the last thing as the crucible comes out of the furnace, and the mixing of the mass is a matter of uncertainty. If the metal is too hot for the zinc a large percentage of it goes off in the form of a greenish cloud of vapour, and the longer the stirring goes on the more escapes. The two metals which enter into the composition of brass have an affinity for each other, but they must be brought into intimate contact before they will combine. Some brassfounders use precautions to prevent volatilisation of the more fusible metals, introducing them under a cover of powdered charcoal on top of the copper.

COMPOSITION OF BRASSES.

Names.	Copper.	Zinc.	Tin.	
German brass (common)	1	1		
Good yellow brass	2	1		
Brass wire	2	1		
Muntz's sheathing-metal	3	2		
Red brass, to be soldered	8	3		
Common brass	3	1		
Pinchbeck	4	1		
Revere's sheathing-metal (1830)	95	5		
Collins's red alloy for sheathing	8	1		
Collins's yellow alloy for sheathing	10	8		
Collins's white alloy for sheathing	1	16	16	
Tough brass for engine work	20	3	3	
Brass for heavy bearings	32	1	5	
Pinchbeck	4	1		
,, ...	5	2		
Tombac	16	1	1	
Red tombac	88·8	11·2		
,, ...	11	1		
Rolled brass	74·3	22·3	3·4	
Tutenag	50	31		19 Ni
Brass gilding-metal (bronze colour)	16	1-1¼		
Emerson's patent brass (English)	16	8		
Statuary brass (Versailles)	91·40	5·53	1·70	1·37 Pb.
Chantrey's hard alloy	32	5	5	
Manheim gold	4	1	¾	
,, ...	3	1		
Semilor	5	1		
Mosaic gold (Hamilton and Parker's patent)	32	33		
Mock platinum		5		8 Brass.
Bath Metal		9		32 Brass.
White brass	10	80	10	
Ormolu	48	52		
Speculum metal (Martin's patent) August 23, 1859	100	19		16 Arg.
Mushet's sheathing metal (1823)	100	⅛		

The proportions are varied, and tin and antimony are added in some of the formulæ.

"Brass-finisher" is a term many understand as applied only to those who produce highly-finished brass work; but it is not so: the brass-finisher's work is not the superior class of

work supposed, most of it being comprised in gas fittings, ormolu mounts, &c., but the highest class of brass-finishing is a totally different process. Fittings for gas-work, all finished well enough for their several purposes, and as well done as the price paid for them will allow, as well as the mountings for furniture, must obviously be produced at a low price, in order to supply the demand for cheap work of this character, most of which is simply dipping, burnishing and lacquering.

Let us follow the process of finishing the highest class of brass work. Before commencing to polish, all marks of the file must be removed, and this is done thus :—Having used a superfine Lancashire file to smooth both the edges and the surfaces, take a piece of moderately fine emery paper and wrap it tightly, once only, round the file. By having many folds round the file the work becomes rounded at the edges, and so made to look like second-rate things. Some use emery sticks, made of pieces of planed wood about $\frac{3}{8}$ inch thick and $\frac{3}{4}$ inch wide, quite flat on the surfaces. They are covered with thin glue, and the emery powdered on to them, and then allowed to dry hard. Most common work is rubbed over, not to say finished, with emery cloth. This will not do for good work. The paper folded once round the file is used in a similar manner to the file, and when the file-marks disappear, and the paper is worn, a little oil should be used, which makes it cut smoother. The edges and surfaces being prepared to this extent, the edges must be finished. To effect this take a piece of flat, soft wood, and apply to its surface a little fine oilstone-powder; be sure that it is quite clean, as it is very annoying to make a deep scratch in the work just as it is finished, perhaps so deep that it will require filing out.

When the work has been finished with the stick and oil-stone-powder, use a clean buff, with rotten-stone and oil; and afterwards dry rotten-stone alone should be used, and a bright,

clean and flat finish is obtained. The surfaces will next have all the marks of the file taken out, and be got quite smooth with emery paper.

The best and most ornamental way of finishing such work is by "curling," a method of work for finishing such metals as brass, German silver, etc., which are used for microscopic and philosophical instruments. If well done, it gives a handsome appearance.

The surface must first be carefully finished so as to have no scratches, as these would show through the curling and destroy the effect. Work is not well finished that is simply very bright but full of scratches. High polish and deep scratches must at all risks be avoided, as these are bad signs on the part of the workman.

After the metal has been finished with fine files, emery-paper, water-of-Ayr stone, and finally the finest rotten-stone applied by means of a buff, the curling is produced by means of a stick of charcoal moved in circular sweeps over the surface, which should be kept well moistened with water.

When the surface is finished by this process, next use a piece of slate-pencil brought to a point. This is also used with water, and is moved in small circles, which are not regularly formed, but interlaced in all directions. After the desired effect has been produced, the metal is lacquered. Curling is applied to surfaces of considerable extent, but the effect is not so good as in the case of small surfaces. Large sweeps give a coarse appearance to the work, while a large surface covered with small sweeps has a confused appearance.

The next operation will be lacquering. After the metal has been well wiped and brushed out with whiting, to take off all the grease, it should be heated until it is too hot for the finger to be held upon it. Well wipe again with a clean, dry rag, as where there is any grease the lacquer will not take, and at

those parts it will show a dirty discoloured mark in a short time. Lacquer the edges first. In using the brush, a very light hand is necessary, and use no more lacquer in the brush than you can help, and be sure that lacquer, brush, pot and work are free from dirt and dust. These directions show how the finish seen on the best work is obtained, and there is really little difficulty in it excepting care, and without that good work of any kind cannot be done.

The process of lacquering is only to preserve the bright surface of the metal by coating it with a layer of varnish. The colour of this varnish may be modified to suit the work to which it has to be applied. Lacquer contains either seedlac or shellac, hence its name. Seedlac is the gum in its original form, and when it has been purified and prepared by moulding into thin sheets it is called shellac. This material may be bleached so as to become almost colourless, but in that condition it is not so strong or effective for lacquering purposes. With regard to applying the lacquer it should be understood that much depends on the condition of the work. Perfect cleanliness and a tolerable polish are necessary to insure a successful application of the lacquer. The work must be heated to about the temperature of boiling water before lacquering, and this must be laid on evenly with a camel-hair brush.

With regard to the lacquer itself—yellow is made by mixing turmeric with lac varnish; gold is made with dragon's blood and lac varnish; red contains a larger proportion of dragon's blood. Lacquers suffer a chemical change through heat and light, and for this reason must be kept in a cool place, and away from the light. The brushes used should always be carefully washed out in methylated spirits, and be kept scrupulously clean. There are innumerable receipts for lacquers. A good pale gold lacquer is made by dissolving 5oz. of seed-

lac in half a gallon of methylated spirits, and then adding a small quantity—less than half an ounce—of red sanders. Allow the whole to thoroughly incorporate, then strain for use. To this lacquer may be added red sanders, dragon's blood, or annatto, for imparting richness of colour. To lower the tone of colour, turmeric, gamboge, saffron, Cape aloes, and sandarac are used. The first group reddens, the second yellows the varnish, while a mixture of the two gives an orange tint. Some receipts for lacquers are given at the close of this chapter.

To prepare brass for lacquering, it is either dipped for an instant in commercial nitric acid, then washed in clean water and dried in sawdust, or immersed in a mixture of one part of nitric acid with four of water, then withdrawn, washed in clean water and dried in sawdust. In the first case the brass will be bright, in the latter a dead flat, which is usually relieved by burnishing the prominent parts. Then the goods are dipped for an instant in commercial nitric acid, and well washed in water containing some argol (to preserve the colour till lacquered) and dried in warm sawdust. So prepared, the goods are heated on a hot plate previous to the lacquering.

Properly-lacquered brass work will retain its colour, and resist the action of the atmosphere for a long time; hence the practice of always lacquering work which should retain a good appearance. The process is rather difficult to execute on large surfaces, where the tyro will find the lacquer continually getting a smeary look.

Lacquering is done in two ways, called cold lacquering and hot lacquering. By the former, a little lacquer being taken on a common camel-hair brush is laid carefully and evenly over the work, which is placed in an oven or on a hot stove; the heat from this continued only a minute or two is sufficient to set the lacquer, and the work is finished. Care must be taken not to have the work too hot so as to burn the lacquer, nor yet

too cold, for in this case the lacquer will not be thoroughly set.

By the second method the work is heated first to about the heat of a flat iron as used by the laundress, and the lacquer quickly brushed over it in this state, the work being afterwards subjected to the oven for a minute or not, according to the pleasure and judgment of the lacquerer. If very small the article will require this, because it will have parted with most of its heat to the lacquer; if heavy it will retain sufficient to perfect the process. The greatest difficulty is to know the exact degree of heat, and this knowledge is only attained by experience, so different is the nature of the materials, the quality of the different lacquers, and the effect to be produced. When work is newly lacquered the lacquer is soft, and the work ought to be exposed to a gentle heat for a short time to evaporate the alcohol and harden the lacquer. Small gas cooking stoves are very suitable for this purpose, and it will be found that after newly lacquered work has been baked for a short time, any little unevenness in the laying on the lacquer will be much improved.

The best kind of brush for lacquering is one made in the following manner: Take a piece of wood, a little broader than the work to be lacquered, and make into the shape of the handle of an ordinary white-wash brush. Cut a slit into it lengthwise with a thick saw; take a narrow strip of clean flannel, as long as the wood is broad, and fold it the longest way; then a piece of white nankeen cloth, and fold it round the outside of the flannel, and put them both in the slit cut in the wood, with their folded edge outward, and fasten the cloth to the wood by means of screws passing through the side. Before fastening tight, put a piece of straight wire, about a quarter of an inch thick, through the bow of the folded cloth, and pull the cloth tight against the wire so as to make it

smooth and straight. After the cloth is fastened tight in the wood, the wire is withdrawn, and the brush is specially fitted to be used for lacquer. The woollen cloth holds the lacquer, while the nankeen cloth prevents it flowing too freely, and also presents a smooth surface to the metal that is to be lacquered, while it prevents any particles coming off the woollen cloth on to the lacquered surface. A brush of this kind must not be dipped into a bowl of lacquer, but the lacquer put on to it by means of a common brush. By means of a brush made in this way, large flat surfaces are lacquered very evenly. First coating the work with alcohol, or very thin lacquer, causes the lacquer, when applied, to flow more easily and regular. The brush must be laid on the work very lightly and with a slight curved motion at the beginning of the stroke, so that it may miss the sharp edge of the work, by which a portion of the lacquer would be pressed out and flow irregularly over the edge. The brush must then be drawn straight, and with equal pressure along the surface of the metal, and be lifted off the instant it reaches the other edge. In moderately broad surfaces a brush the full breadth of the work should be used; but in very wide surfaces, and where there are a number of large holes in the work, a brush is difficult to use.

The best method of cleaning old brass-work is by "dipping." The pickle consists of a mixture of one part common nitric acid and one part sulphuric acid in a stone jar; then place ready a pail of fresh water and a box of sawdust. Dip the articles to be cleaned in the acid, which quickly dissolves the metal, leaving a bright untarnished surface. After dipping, the brass is swilled in clean water to arrest the action of the acid. The work must be carried on in the open air, or under a freely-vented flue, as the fumes given off are very baneful to health.

When re-lacquering old brass-work, take the article to pieces

as far as possible, leaving no iron screws or pins in it. If the brass is greasy it must be first dipped in a strong solution of potash and soda in warm water, and then put it into a copper or saucepan containing a lye made of ½lb. of potash with one gallon of water. Let the article boil in this lye for about twenty minutes, to remove the old lacquer, then take it out and dip it in clean cold water. This cleans the metal so that the acid has the power to act. The operation of dipping in acid and swilling is repeated till the surface of the metal is considered to be thoroughly clean and bright; after the last swilling, the brass-work is dried in hot sawdust, then it is finally lacquered with gold lacquer. The surface as left from the action of the acid, will, when lacquered, present the clean dull surface; the bright parts are got up so by the aid of a steel burnisher, applied before the lacquer, of course.

To prevent the rusting of brass goods, means of protecting the surface from the action of the atmosphere is necessary. Brass, left in damp sand, acquires a beautiful brown colour, which, when polished with a dry brush, remains permanent and requires no cleaning. A green and light coating of verdigris can be imparted to the surface of the brass by means of dilute acids, allowed to dry spontaneously. The antique appearance thus given is more or less permanent. Before bronzing, all the requisite fitting is finished, and the brass annealed, pickled in old or dilute nitric acid, scoured with sand and water, and dried. Bronzing is then performed according to the colour desired; for, although the word means a brown, in commercial language it includes all colours.

Browns of all shades are obtained by immersion in solution of nitrate or perchloride of iron, the strength of the solution determining the depth of the colour. Violets are produced by dipping in a solution of chloride of antimony. Chocolate is obtained by burning on the surface of the brass moist red

oxide of iron, and polishing with a very small quantity of blacklead.

Olive-green results from making the surface black by means of a solution of iron and arsenic in muriatic acid, the details of the process being as follows: Make the articles bright, then dip in nitric acid, which must be thoroughly rinsed off with clean water. Then make the following mixture: Hydrochloric acid, 6lb.; sulphate of iron, ½lb.; white arsenic, ½lb. All the ingredients to be pure. Let the articles lie in the mixture till black; take out and dry in hot sawdust, polish with blacklead, and lacquer with green lacquer.

A steel-grey colour is deposited on brass from a dilute boiling solution of chloride of arsenic; and a blue by treatment with strong hyposulphite of soda.

Black is much used for optical brasswork, and is obtained by coating the brass with a solution of platinum, or with chloride of gold mixed with nitrate of tin. The Japanese bronze their brass by boiling it in a solution of sulphate of copper, alum and verdigris.

Success in the art of bronzing greatly depends on such circumstances as the temperature of the alloy and of the solution, the proportions of the metals used in forming the alloy, and the quality of the materials. The moment at which to withdraw the goods, and the drying of them, require attention which experience alone can impart.

The following will be found useful lacquers for brass. Of course smaller quantities can be made by keeping the proportions of the ingredients relatively the same: (1) Seedlac, dragon's blood, annatto and gamboge, of each 4oz., saffron 1oz., alcohol 10 oz. (2) Turmeric 1lb., annatto 2oz., shellac and gum juniper, of each 12oz., alcohol 12oz. (3) Seedlac 6oz., dragon's blood 40gr., amber or copal (ground on porphyry) 2oz., extract of red sandalwood 30gr., Oriental saffron 36gr.,

pulverised glass 4oz., purest alcohol 40 oz. (4) Seedlac 3oz., amber and gamboge of each 2oz., extract of red sanders ½dr., dragon's blood 1dr., saffron ½dr., alcohol 4oz. (5) Turmeric 6dr., saffron 15gr., alcohol 1 pint; draw the tincture (*i.e.*, dissolve these two in the alcohol to form a tincture of them) and then add gamboge 6dr., gum sandarach and gum elemi each 4oz., dragon's blood and seedlac of each 1oz. (6) Put into a pint of alcohol 1oz. of turmeric powder, 2dr. of annatto, and 2dr. of saffron: agitate daily for a week, and filter into a clean bottle. Now add 3oz. of clean seedlac, and agitate the bottle every day for a fortnight. (7) ½oz. of gamboge, 1½oz. of aloes, 8oz. fine shellac, 1 gallon alcohol.

CHAPTER V.

SOLDERS AND SOLDERING.

THE term *soldering* is generally applied when fusible alloys of lead and tin are employed for uniting metals. When hard metals, which melt only above a red heat, such as copper, brass, or silver, are used, the term *brazing* is sometimes used.

Hard soldering is the art of soldering or uniting two metals or two pieces of the same metal together by means of a solder that is almost as hard and infusible as the metals to be united. In some cases the metals to be united are heated, and their surface united without solder by fluxing the surfaces of the metals. This process is then termed burning together. Some of the hard soldering processes are often termed brazing. Both brazing and hard soldering is usually done in the open fire on the brazier's hearth. A soldered joint is more perfect and more tenacious as the point of fusion of the solder rises. Thus tin, which greatly increases the fusibility of its alloys, should not be used for solders, excepting when a very easy running solder is wanted. Solders made with tin are not so malleable and tenacious as those prepared without it.

The Egyptians soldered with lead as long ago as B.C. 1490, the time of Moses. Pliny refers to the art, and says it requires the addition of tin to use as a solder. The tin came mainly from the Cassiterides (Cornwall).

Plumbers use solder composed of two parts of lead and one of tin, and a very slight variation in these quantities makes

a very considerable difference in the working, and also in the soundness of the joint. If a slight excess over the above proportion of lead is used, the solder is more difficult to work, and the joint, when made, frequently leaks, the water passing through the small cellules or pores in the metal, and the joint is then said to "sweat." If an excess of tin is used, the solder melts too easily, and considerable difficulty is found in keeping it on the joint, and it cools so suddenly that the joints always look rough and ragged at the ends. They sometimes require trimming up to make them look better; this solder also keeps running, and then congealing, in such a way as to be difficult to keep it at a workable heat. Small portions of the metal also keep sticking to the cloth used for moulding, technically called wiping, the joint or seam, as the case may be. Plumbers' solder, with the above proportions, on being melted, and then allowed to cool, will generally exhibit several bright spots on its surface, due to the two metals partly separating. These bright spots are generally a very sure guide as to the proper quantities of each metal used. If none are seen, it is too coarse; and if too many are seen, it contains too much tin and is said to be too fine. If the spots are small, the metal may not be good, although it may have beyond its proper quantity of tin; but if the spots are about the size of a threepenny-piece the solder very rarely fails to work well.

In uniting tin, copper, brass, &c., with any of the soft solders, a copper soldering-bit is generally used. This tool and the manner of using it are well known. In many cases the work may be done more neatly without the soldering bit, by filing or turning the joints so that they fit closely, moistening them with the soldering fluid described hereafter, placing a piece of smooth tin foil between them, tying them together with binding-wire, and heating the whole in a lamp or fire till

the tin-foil melts. Pieces of brass are often joined in this way, so that the joints are invisible. With good soft solder, almost all work may be done over a spirit-lamp, or even a candle, without the use of a soldering-bit.

Advantage may be taken of the varying degrees of fusibility of solders to make several joints in the same piece of work. Thus, if the first joint has been made with fine tinner's solder, there would be no danger of melting it in making a joint near it with bismuth solder. The fusibility of soft solder is increased by adding bismuth to the composition. An alloy of lead 4 parts, tin 4 parts, and bismuth 1 part, is easily melted; but this alloy may itself be soldered with an alloy of lead 2 parts, bismuth 2 parts, and tin 1 part. By adding mercury a still more fusible solder can be made. Equal parts of lead, bismuth and mercury, with two parts of tin, will make a composition which melts at 122° Fahr.; or an alloy of tin 5 parts, lead 3 parts, and bismuth 3 parts, will melt in boiling water. In melting these solders, melt the least fusible metal first in an iron ladle, then add the others in accordance with their infusibility.

It is convenient—and, in fact, often necessary—to have solders which will melt at different degrees of temperature, to avoid the risk of spoiling the work by subjecting it to too great a heat, when, with a little easy-flowing solder there would be no danger. The following table gives proportions, &c., and it will be found very convenient to have some of the sorts on hand ready for use.

Tin 1	...	...	Lead 25	...	Melts at	580° F.
,, 1	...	...	,, 10	...	,,	540°
,, 1	...	...	,, 5	...	,,	510°
,, 1	...	...	,, 3	...	,,	480°
,, 1	...	...	,, 2	...	,,	440°
,, 1	...	...	,, 1	...	,,	370°

Tin $1\frac{1}{2}$	...	...	Lead 1 ...	Melts at	335° F.
" 2	...	...	" 1 ...	"	340°
" 3	...	...	" 1 ...	"	355°
" 4	...	...	" 1 ...	"	365°
" 5	...	...	" 1 ...	"	375°
" 6	...	...	" 1 ...	"	380°
" 4	...	Bismuth 1	" 4 ...	"	320°
" 3	...	" 1	" 3 ...	"	310°
" 2	...	" 1	" 2 ...	"	290°
" 1	...	" 1	" 1 ...	"	255°
" 1	...	" 2	" 2 ...	"	235°
" 5	...	" 3	" 3 ...	"	200°

Either can be melted in an iron ladle, and cast in strips for convenience in applying. Any of them will flow readily with the ordinary fluid. To cast strips of solder, pour the molten metal on a flat surface of stone or metal, drawing the ladle along the while, to leave a thread of metal of the desired substance.

The following simple mode of making solder wire, which is very handy for small work, will be found useful: Take a sheet of stiff writing or drawing paper and roll it in a conical form, rather obtuse; make a ring of stiff wire, to hold it in, attaching a suitable handle to the ring. The point of the cone must be cut off to leave an orifice of the size required. When filled with molten solder it should be held above a pail of cold water, and the stream of solder flowing from the cone will congeal as its runs and form the wire. If held a little higher, so that the streams of solder breaks into drops before striking the water, it will form handy, elongated "tears" of metal; but, by holding it still higher, each drop forms a thin concave cup or shell, and, as each of these forms have their own peculiar uses in various purposes, many will find this hint very useful.

In using ordinary tinner's solder for uniting surfaces that are already tinned—such as tinned iron plate and tinned copper—resin is the best and cheapest flux, but when surfaces of iron, brass, or copper, that have not been tinned are to be joined by soft solder, soldering fluid is by far the most convenient. Resin possesses this important advantage over soldering fluid, that it does not induce subsequent corrosion of the article to which it is applied. When acid fluxes have been applied to anything that is liable to rust, it is necessary to see that they are thoroughly washed off with clean warm water, and the articles carefully and throughly dried. Oil and powdered resin mixed together make a good flux for tinned articles. The mixture can be appled with a small brush or a swab, tied to the end of a stick.

For soft solders the best flux is a soldering fluid, which may be prepared by saturating hydrochloric acid (spirit of salt) with zinc. The addition of a little sal-ammoniac improves it. A solution of phosphoric acid in alcohol makes, it is said, an excellent soldering fluid, which has some advantages over chloride of zinc. To prepare the latter put $\frac{1}{2}$ pint of muriatic acid (also called spirits of salts and hydrochloric acid) into a glass, and add small pieces of clean zinc, which will be dissolved by the acid. Let it stand for several hours, till the acid has ceased to act; then add a small quantity of water—say a wineglass full — when ebullition will recommence. Let it stand undisturbed for a few hours, and again add a small quantity of water. Continue this until the quantity of water added equals that of the acid ($\frac{1}{2}$ pint). When all action has ceased, add 1oz. of sal-ammoniac; let it stand 12 hours, then decant the clear liquid into a bottle, which should be kept well fastened when not in use. Throw away the sediment.

Soft solders do not make malleable joints. To join brass,

copper, or iron, so as to have the joint very strong and malleable, hard solder must be used. For this purpose equal parts of silver and brass will be found excellent, though for iron, copper, or very infusible brass, use silver coin rolled out thin, which may be done by any silversmith or dentist; this makes decidedly the toughest of all joints, and as a little silver goes a long way it is not very expensive.

When soldering work of copper, iron, brass, etc., the solder generally used is a fusible brass, and the work to be soldered is prepared by filing or scraping perfectly clean the edges or parts to be united. The joints are then put into proper position and bound securely together with binding-wire or clamps; the granulated spelter solder and powdered borax are mixed in a cup with a very little water and spread with a strip of sheet metal or a small spoon along the joint to be united. The work is then placed upon a clear fire and heated gradually, to evaporate the water used with the solder and borax and also to drive off the water contained in the crystallised borax, which causes it to boil up with a frothy appearance. If the work is heated hastily the boiling of the borax may displace the solder, and for this reason it is better to roast the borax before mixing with the solder. When the borax ceases to boil, the heat is then increased, and when the metal becomes a faint red, the borax fuses quietly like glass; and shortly after, as the heat of the metal is increased to a bright red, the solder also fuses, which is indicated by a small blue flame, from the burning of the zinc. Just at this time the work should be jarred slightly by being tapped lightly with the poker or hammer, to put the solder in vibration and cause it to run into the joint. For some work there is no necessity to tap it, for the solder is absorbed into the joint without.

Silver soldering, as applied to silversmith's work, requires great care and practice to perform neatly and properly. The

solder should in every way be well suited to the particular metal to which it is to be applied, and should possess a powerful chemical affinity to it; if this is not the case, strong, clean and invisible connections cannot be affected, and that is partly the cause of roughness in goods, and not, as may more frequently be supposed, from the want of skill on the part of the workman. The best connections are made when the metal and solder agree as nearly as possible in uniformity as regards fusibility, hardness and malleability.

The ordinary blowpipe is a tapering tube about eight inches long and one third of an inch diameter at the largest end. The small end is perforated with a pin hole. The uses of the blowpipe are various, but it is principally used in hardening and tempering, and in soldering.

For soldering small articles of jewellery, the common blowpipe, such as may be bought at any tool shop for about sixpence, is used. The solder is sold at dealers' in jewellers' requisites, ready for use. Of solder for silver goods, several sorts are used, in different qualities to suit different work. Only specify the purpose for which it is intended to be used when buying, and the correct quality will be given. Gold solder, to be used for gold jewellery, is subject to the same conditions. Gold solders are made from gold of the quality of the article, say 18 or 16 carats, to which is added $\frac{1}{12}$ of silver and $\frac{1}{24}$ of copper; or a larger proportion of silver and copper for ware of inferior fineness.

The quality of the solder is always a trifle less than the metal on which it is to be used. This is necessary, in order that the solder may melt before the article does. The flux used with both gold and silver solders is borax. Working jewellers generally rub a lump of borax on a piece of slate with a few drops of water, just as water colours are ground, to a cream-like consistency. The solder is scraped clean, to re-

move all trace of oxide, cut into little pieces and mixed with the borax. The actual process of soldering will be modified to suit the peculiarities of the article which is to be treated. Usually the edges to be soldered are cleaned, wetted with the borax fluid, and placed closely in contact. If possible the article is bound tightly together with binding-wire. This is fine wire of soft iron, made specially for such purposes. A piece of pumice-stone or charcoal is used to rest the work on whilst it is being heated. It is laid on this, with the joint uppermost; a few pieces of solder and a little borax are placed along the joint, and the article is ready for being heated. So long as there is sufficient for the purpose, the less solder and borax used the better. Gas is generally used for heating with, but failing that, a spirit lamp will answer for all small work. A small lamp suited for the purpose, to burn methylated spirit, can be bought for a shilling. With the blowpipe direct a jet of flame along the joint, at the same time heating the entire article till the solder runs, then the soldering is accomplished.

Solders made from silver and copper only are, as a rule, too infusible to be applied to the general run of silver goods. Solders are manufactured of all degrees of hardness. Hardest: Four parts of fine silver and one of copper; or three parts of sterling silver and one of brass wire. Soft: Two parts of fine silver and one of brass wire. Three-quarters of a part of arsenic is sometimes added at the close of the operation to make the solder whiter and more fusible; but its poisonous vapours render its use injudicious. In applying solder, of whatever composition, it is of the utmost importance that the edges, or parts to be united, should be chemically clean; and for the purpose of protecting these parts from the action of the air and oxidation during the soldering process they are covered with a flux, always borax, which not only effects the

objects just pointed out, but greatly facilitates the flow of the solder to the required places. Silver may be soldered with silver of a lower quality, but easy-running solder may be made of 13 dwt. fine silver, 6 dwt. of brass; the composition of brass being so uncertain, it is best to fuse zinc and copper with the silver, and the following proportions make a very easy-running solder: 12 dwt. fine silver, 6 dwt. pure copper, 1 dwt. zinc. Brass sometimes contains lead, which burns away in soldering, and must be carefully guarded against. Solder for filigree work is prepared by reducing easy-flowing solder filings and mixing it with burnt borax powdered fine. In this state it is sprinkled over the work to be soldered, or the parts to be soldered are painted with wet borax, and the solder filings are sifted on and adhere to the borax. The flux which adheres to the work after soldering is removed by boiling the articles in a pickle of sulphuric acid and water, 1 part to 30.

Steel or heavy iron may be united in the same way at a very low heat. For soldering iron, steel and other light coloured metals, and also brass work that requires to be very neatly done, the silver solder is generally used on account of its superior fusibility and combining so well with nearly all metals, without gnawing or eating away the sharp edges of the joints. Silver solder is used a great deal in the arts, and from the sparing or careful way in which it is used most work requires but little or no finish after soldering; so that the silver solder, although expensive, is in reality the cheapest solder in the end. For silver soldering the solder is rolled into thin sheets and then cut into narrow strips with shears. The joints or edges to be united are first coated with pulverised borax, which has been previously heated or boiled to drive off the water of crystallisation. The small strips of solder are then placed with forceps upon the edges or joints to be united, and the work is then heated upon the brazier's hearth. The process

of silver soldering upon the larger scale is essentially the same as the operation of brazing.

For hard soldering small work, such as drawing instruments, jewellery, buttons, etc., the blowpipe is almost exclusively used, and the solder used is of the finest or best quality, such as gold or silver solder, which is always drawn into thin sheets of very fine wire, and it is sometimes pulverised or granulated by filing; but solder should not be pulverised very fine; a greater degree of heat is always required to fuse a minute particle of metal than is required to fuse a large piece.

In soldering jewellery, the borax or other flux is usually applied in solution with a small camel's-hair brush. The solder is rolled into very thin sheets, and then clipped into minute particles of any desired shape or size, which is so delicately applied to the work that it is not necessary to file or scrape off any portion of it, none being in excess. The borax or other flux used in the operation is removed by rubbing the work with a rag that has been moistened with water or diluted acids.

To obtain hard solders of uniform composition they are generally granulated by pouring them into water through a wet broom. Sometimes they are cast in solid ingots and reduced to powder by filing. Silver solders for jewellers are generally rolled into thin plates, and sometimes the soft solders, especially those that are very fusible, are rolled into sheets and cut into narrow strips, which are very convenient for small work that is to be heated by a lamp.

In order to do good work it is necessary to apply the heat as uniformly as possible, so as to have the solder melt uniformly. This is done by moving the work about in the fire. As soon as the work has been properly heated and the solder has fused, the work should be removed from the fire, and after the solder has set it may be cooled in water without injury. Tubes to be soldered are generally secured by binding

wire, twisted together around the tube with pliers. All tubes that are soldered upon the open fire are soldered from within, for if they were soldered from the outside the heat would have to be transmitted across the tube with greater risk of melting the lower part of the tube, the air in the tube being a bad conductor of heat. In soldering long tubes the work rests upon the flat plate of the brazier's hearth, and portions equal to the length of the fire are soldered in succession.

The best solder for platinum is fine gold. The joint is not only very infusible, but it is not easily acted upon by common agents. For German silver joints, an excellent solder is composed of equal parts of silver, brass and zinc. The proper flux is borax.

Solders.	Gold.	Silver.	Copper.	Tin.	Zinc.	Lead.	Bismuth.	Brass	Melting-point.
Pewterer's				2		1	2		360°
Pewterer's, soft				3		4	1		
" "				2		1			
Tinman's				1		1			393
Coarse				1		3			500
Plumber's				1		2			475
Hard Spelter			4		3				1,869
Gold*	6	1	2						
For Brazing Steel		19	1					2	
Hardest Silver		4	1						
Hard Silver		3						1	
Soft Silver		2						1	
For Aluminium		2		2	1	2			

In preparing solders, whether hard or soft, great care is requisite to avoid two faults—a want of uniformity in the melted mass, and a change in the proportions of the constituents by the loss of volatile or oxidable ingredients. Thus,

* Various proportions are employed, according to the fineness of the article, so as not to risk the test of assay.

where copper, silver and similar metals are to be mixed with tin, zinc, etc., it is necessary to melt the more infusible metal first. When copper and zinc are heated together, a large portion of the zinc passes off in fumes. In preparing soft solders the material should be melted under tallow to prevent waste by oxidation; and in melting hard solders the same object is accomplished by covering them with a thick layer of powdered charcoal.

The common iron tubes for gas-pipes are soldered or welded from the outside. This is done by heating the tube in a long air furnace, completely surrounded by hot air, by which means the tube is heated more uniformly than in the open fire. After the tubes have been heated to the welding heat they are then taken out of the furnace and drawn through clamps or tongs to unite the edges, and are then run through grooved rollers two or three times, and the process is complete. The soldering or welding of iron tubes requires much less precaution in respect of the heat than some of the other metals or alloys, for there is little or no risk in fusing it. In soldering light iron-work, such as locks, hinges, etc., the work is usually covered with a thin coating of loam to prevent the iron from being scaled off by the heat. Sheet iron may be soldered at a cherry-red heat, by using iron filings and pulverised borax as a solder and flux. The solder and flux are laid between the irons to be soldered, and the whole is bound together with binding wire and heated to a red heat and taken from the fire and laid upon the anvil, and the two irons are united by a stroke upon the set hammer.

Hard solders are usually reduced to powder, either by granulation or filing, and then spread along the joints after being mixed with borax, which has been fused and powdered. It is not necessary that the grains of solder should be placed *between* the pieces to be joined, as with the aid of the borax

they will "sweat" into the joint as soon as fusion takes place. The same is true of soft solder applied with a soldering fluid. One of the essential requisites of success, however, is that the surfaces be clean, bright, and free from all rust.

Soldering without heat, commonly called cold soldering, is a process not only possible but common, and after the first preparation is exceedingly simple. The process given has many uses for soldering all articles which cannot be exposed to heat, and for soldering parts together which cannot be got at with either a copper bit or a blowpipe flame.

The process of cold soldering can be extended even to soldering two faces of *dirty cast iron* together. It may be done on blocks of any size without the slightest assistance so far as heating is concerned, by the following process.

Although the first preparation is tedious a large quantity of the materials can be made at once, and the actual soldering process is simple and quick. Flux: 1 part metallic sodium to 50 or 60 parts mercury. This must be kept in a stoppered bottle closed from the air. It has the property of amalgamating (equivalent to tinning by heat) any metallic surface, cast iron included.

Metallic sodium alloys with mercury by being shaken up in a bottle with it. If this is too much trouble the sodium amalgam can be bought ready made from any chemist or dealer in reagents.

Solder: make a weak solution of sulphate of copper about 1oz. to 1 quart of water. Precipitate the copper by rods of zinc; wash the precipitate 2 or 3 times with hot water; drain the water off, and add for every 3 ounces of precipitate 6 or 7 ounces of mercury; add also a little sulphuric acid to assist the combination of the two metals. The finely-divided copper combines with the mercury, and they form a paste which sets intensely hard in a few hours, and whilst soft this paste should

be made into small pellets, which harden and have the property of softening by heat and again hardening in a few hours.

When wanted for use heat one or more of the pellets until the mercury oozes out from the surface in small beads, shake or wipe these off, and rub the pellet into a soft paste in a small pestle and mortar, or by any other convenient means, until it is as smooth and soft as painters' white lead. This when put on the surface amalgamated by the sodium and mercury adheres firmly and sets perfectly hard in about three hours. The joint can be parted if necessary, either by a hammer and cold chisel or by a heat about sufficient to melt plumber's solder.

If expense is no object there is no difficulty in making a much stronger solder, which will set hard in 15 minutes. For this quick setting solder to replace the copper and mercury use 8 silver, 10 tin, 1 bismuth, 1 platinum, melted together, cast into an ingot, and reduced to fine filings. When wanted mix about 3 parts filings and 1 mercury in a small mortar until it becomes a smooth paste. This sets in about 15 minutes, and cannot be made workable again by heat; it must be mixed just as required. The omission of the platinum reduces the strength of the solder and lengthens the time required to harden to about 1 hour. The omission of bismuth makes a more granular mass, which is better for filling up crevices. With bismuth it is as smooth and plastic as potter's clay.

CHAPTER VI.

FILES AND FILING.

FILES are of very ancient origin, and these tools are mentioned in the Book of Samuel. They are made in endless variety for special purposes, but there are a few generally accepted peculiarities by which files can be classified. These are *length*—which is measured from the point to the heel exclusive of the tang; *kind*—which really indicates the shape of the longitudinal and sectional forms; *cut* — which varies not only in coarseness but in kind.

The five grades most in use are divided as follows:—Rough, bastard, second cut, smooth, and dead smooth. The teeth of ordinary files called double cut are made by two separate series of grooves cut on the file, which form a diamond-shaped tooth. The first cut which is put on the file is known as the "over cut," and the second as the "up cut." For saw files, only the "over cut" is used, the tooth being a sharp ridge of metal extending at a angle across the face of the file; these are called single cut. The teeth are not intersected by any other stroke of the cutting chisel. Single cut files have two grades, bastard and second cut. The other tooth which is in use is that applied to horse rasps, wood rasps, cabinet rasps, and shoe rasps. This tooth is raised to a conical form by the use of a punch. On horse rasps it is too large to designate by any grade of cut. On wood and cabinet rasps it is graded as bastard, smooth, and sometimes second cut. As a matter of convenience, the number of teeth is given by counting only

one of the cuts of the file, and this is the "over cut," or first cut.

Gradation of coarseness depends on the length of the file: thus bastard files of the undermentioned lengths have the number of teeth shown per running inch.

4 in.	8 in.	12 in.	16 in.	long.
76	56	48	44	teeth per inch.

The teeth of files may be single cut, double cut, or rasp cut, each of which is quite distinct.

The length of a file gives no clue to any other dimensions, and the file may be of any section or substance.

The kind is a term having technical significance as flat, square, round, etc.; some are named from their transverse section, some from the purpose for which they are intended. Some of the files generally used are described below.

Square.—A double cut file, made up of the five grades of cut previously mentioned, namely, rough, bastard, second cut, smooth and dead smooth.

It is of equal width and thickness for about two-thirds its length; from there to the end it is gradually drawn to a point, its square shape being retained. Frequently the point or end is left of the same thickness as the tang end. It is then called "parallel square."

Pillar.—A file in cut and grade of cut the same as "flat." In other respects the same as a "hand," with two exceptions. It is only from $\frac{5}{8}$ to $\frac{3}{4}$ the width, and in proportion to its width is of greater diameter than a "hand."

Cotter or Pivot.—A file in cut and grade of cut the same as a "flat." In shape a very narrow "pillar."

Hand.—A file in cut and grade of cut the same as "flat." It is of the same width at the point or end as at the shank or tang end. It is gradually drawn down in thickness from about two-thirds its length to the end, leaving it at the end about

one-half its original thickness. Sometimes it is drawn very slightly from the centre to the tang as regards its thick ness. One edge of the file is left uncut, and given the name of "safe edge." These files are sometimes made with two safe edges.

Flat.—A file in cut and grade of cut the same as "square." The double cut applies to the sides of the file, the edges being single cut; on special orders the file is made with single cut sides and of the five above-mentioned grades. In shape, this file is, as a rule, of parallel sides and thickness for two-thirds its length, and from that distance to the end is drawn to a blunt point, in a gradual decreasing width and thickness.

Warding File.—A file in cut and grade of cut the same as "flat." It is seldom made over eight inches in length. In appearance very much like a flat file—differing in three ways. It is forged more to a point than a "flat," and compared with the same length of "flat" file, is not so thick but has more width.

Equaling.—A file in cut and grade of cut the same as "flat." In every other respect, with one exception, the same as "hand." It is not only of parallel width, but of parallel thickness.

Joint File.—In shape a thin "equaling." It is cut on the edges only, and is sometimes made with round and sometimes with square edges, according to the wishes of the buyer. It is known also as a "drill" file. As regards thickness it can be ordered by numbers, according to Stubs's metal gauge.

Round.—A file in grade of cut the same as "flat," the cut being made up or comprising a number of rows of single cuts extending from shank to point, the rows slightly intersecting. It is gradually drawn to a point, from about two-thirds its length to the end. Sometimes the file is left the same thick-

ness at the point or end as at the tang end; it is then called "parallel round."

Half Round.—A file in grade of cut the same as "flat." It is cut on the flat side the same as a "flat" file, or double cut. On the half round side is a series of rows of single cuts from shank to point, completely covering it. Some of the rows intersect at different angles; where this occurs it gives the file the appearance of being double cut. In shape, of the same width as the various sizes of "flat" files; and drawn to a point in the same way as a "flat" file, only differing from a "flat" in being between a half round and half oval.

Crossing.—A file graded the first as flat. Oval in shape, with two sharp edges, being forged and drawn gradually, from about two-thirds its length to the point. It is cut the same as the back or half round side of the "half round" file.

Triangular, generally miscalled Three Square.—A file in cut and grade of cut the same as "flat." It is in dimensions of triangular shape, giving the file three sharp corners, which vary in sharpness according to grade of cut. It is of uniform dimensions for about two-thirds its length, and is drawn gradually to a point from that distance to the end. There are also "parallel triangular" files, these files being the same thickness at the point as at the tang end.

Saw.—A single cut file, generally of two grades; bastard and second cut, and sometimes a smooth cut. It is flat in shape, slightly drawn at the point, both in thickness and in width, and though of about the same width as a flat file is not so thick. It is generally cut with one round and one square edge, very often with both edges square, and sometimes with both round edges and with one safe edge. By machinists it is often called a "float file."

Taper Saw.—A file sold largely under the following heads: Taper saw, single cut, slim taper saw single cut, band taper

saw single cut, and taper saw double cut. As a rule a file of single cut graded as second cut. It is often cut in all its shapes with a double cut graded as second cut. It is triangular in shape, being forged to a point the same as a "triangular."

Taper Saw Single Cut.—A file graded as "second cut," triangular in shape, being cut on the three sides, also cut on three edges. As a rule, cut within a short distance of the end.

Slim Taper Saw Single Cut.—The same in every particular as the "taper saw," only made from steel two-thirds as heavy.

Band Taper Saw Single Cut.—Is the same as "taper saw" in shape; the sides are cut the same as "taper saw." Its edges are ground, rounding and cut with two rows of teeth to each edge.

Double Cut Taper Saw.—A file in shape the same as "taper saw," the edges being cut, and the sides receiving a double cut "second cut" instead of single cut.

Wood Rasps.—In shape, both flat, round, and half round, and corresponding in this particular to the "flat," "round" and "half round" files. The tooth is conical, being raised from the surface of the rasp with a punch, raising a tooth about equal to the space it removes from the surface. As regards grade of cut, is generally known as "bastard."

Cabinet Rasps.—In every respect but two the same as a "wood rasp." Instead of being "half round" it is scant "half hollow," and in grade of tooth it is a "smooth," sometimes a "second cut."

Cabinet File.—In shape like a cabinet rasp. On flat side it is double cut, and grade of "bastard." On the oval side it is the same grade of cut or bastard half round.

Small single cut files or "floats" of various shapes not hardened may be met with at some of the dealers in watchmaker's tools, which are useful in finishing small articles in

hard wood, ivory, and also in gold and silver; they are used sometimes by jewellers for finishing, on account of their leaving a smooth surface behind them instead of a rough one, as a double cut file does.

In the manufacture of files the pieces of steel, or the blanks intended for files, are forged from bars of steel that have been either tilted or rolled as nearly as possible to the sections required, so as to leave but little to be done at the forge; the blanks are afterwards annealed with great caution, so that in neither of the processes the temperature known as blood-red heat may be exceeded. The surfaces of the blanks are now rendered accurate in form and quite clean in surface either by filing or grinding. For smaller files the blanks are mostly filed into shape as the more exact method; for the larger, the blanks are more commonly ground on large grindstones as the most expeditious method; in some cases the blanks are planed in the planing machine, for those called "dead-parallel files." The blank, before being cut, is slightly greased, that the chisel may slip freely over it. The file cutter is seated before a square stake or anvil, and places the blank straight before him, with the tang towards his person; the ends of the blank are fixed down by two leather straps or loops, one of which is held fast by each foot.

The chisels commonly used in cutting files vary considerably. The largest is a chisel for large rough files; the length is about 3in., the width about 2½in., and the angle of the edge about 50°; the edge is perfectly straight, but the one bevel is a little more inclined than the other, and the keenness of the edge is rounded off, the object being to indent rather than cut the steel; this chisel requires a hammer of about 7 or 8 pounds weight. The smallest is the chisel used for small superfine files; its length is 2in., the width ½in.; it is very thin, and sharpened at about the angle of 35°; the edge is

also rounded, but in a smaller degree; it is used with a hammer weighing only 1 or 2 ounces; as will be seen, the weight of the blow mainly determines the distance between the teeth. Other chisels are made of intermediate proportions, but the width of the edge always exceeds that of the file to be cut.

The first cut is made at the point of the file; the chisel is held in the left hand, at a horizontal angle of about 55° with the central line of the file, and with a vertical inclination of about 12° to 4° from the perpendicular. The following are the usual angles for the vertical inclination of the chisels, namely: For rough rasps, 15° beyond the perpendicular; rough files, 12°; bastard files, 10°; second cut files, 5°; and dead smooth cut files, 4°.

The blow of the hammer upon the chisel causes the latter to indent and slightly to drive forward the steel, thereby throwing up a trifling ridge or burr; the chisel is immediately replaced on the blank, and slid from the operator until it encounters the ridge previously thrown up, which arrests the chisel or prevents it from slipping further back, and thereby determines the succeeding position of the chisel. The chisel having been placed in its second position, is again struck with the hammer, which is made to give the blows as nearly as possible of uniform strength, and the process is repeated with considerable rapidity and regularity, 60 to 80 cuts being made in one minute, until the entire length of the file has been cut with inclined parallel and equidistant ridges, which are collectively denominated the "first course." So far as this one face is concerned, if intended to be single-cut, the file would be then ready for hardening.

The teeth of some single cut files are much less inclined than 55°; those of floats are in general at right angles across the face. Most files, however, are double cut, and have two

series of courses of chisel cuts, and for these the surface of the file is now smoothed by passing a smooth file once or twice along the face of the teeth, to remove only so much of the roughness as would obstruct the chisel from sliding along the face in receiving its successive positions, and the file is again greased.

The second course of teeth is now cut, the chisel being inclined vertically as before, or at about 12°, but horizontally about 5° to 10° from the rectangle. The blows are now given a little less strongly, so as barely to penetrate to the bottom of the first cuts, and consequently the second course of cuts is somewhat finer than the first. The two series of courses cover the surface of the file with teeth which are inclined toward the point of the file, and when highly magnified they much resemble in character the points of cutting tools generally. If the file is flat and to be cut on two faces, it is now turned over, but to protect the teeth from the hard face of the anvil a thin plate of pewter is interposed. Triangular and other files require blocks of lead having grooves of the appropriate sections to support the blanks, so that the surface to be cut may be placed horizontally. Taper files have the teeth somewhat finer toward the point, to avoid the risk of the blank being weakened or broken whilst being cut, which might occur if much force were used in cutting the teeth at the point of the file as in those at its central and stronger part.

Eight courses of cuts are required to complete a double cut rectangular file that is cut on all faces, but eight, ten, or even more courses are required in cutting only the one rounded face of a half round file. There are various objections to employing chisels with concave edges, and in cutting round and half round files, the ordinary straight chisel is used and applied with its edge as a tangent to the curve. It will be found that in a smooth, half round file 1 in. in width, about 20 courses

are required for the convex side, whilst two courses alone serve for the flat side. In some of the double cut, gullet-tooth saw-files, as many as 23 courses are sometimes used for the convex face, and but two for the flat. The same difficulty occurs in a round file, and the surfaces of curvilinear files do not therefore present, under ordinary circumstances, the same uniformity as those of flat files. Hollowed files are rarely used in the arts, and, when required, it usually becomes imperative to employ a round-edged chisel, and to cut the file with a single course of teeth.

The teeth of rasps are cut with a punch, which, for a fine cabinet rasp, is about $3\frac{1}{2}$in. long and square at its widest part. Viewed in front, the two sides of the point meet at an angle of about 60°; viewed edgewise, the edge forms an angle of about 50°, the one face being only a little inclined to the body of the tool. In cutting rasps, the punch is sloped rather more from the operator than the chisel in cutting files, but the distance between the teeth of the rasp cannot be determined, as in the file, by placing the punch in contact with the burr of the tooth previously made. By dint of habit, the workman moves—or, technically, hops—the punch the required distance; to facilitate this movement he places a piece of woollen cloth under his left hand, which prevents his hand from coming immediately in contact with the anvil. The teeth of rasps are cut in rather an arbitrary manner, and to suit the custom rather than the necessities of the workmen who use them. Thus the lines of teeth in cabinet rasps, wood rasps, and farriers' rasps are cut in lines sloping from the left down to the right-hand side; the teeth of rasps for boot and shoemakers and saddle-tree-makers are cut in circular lines, or crescent form. These directions are quite immaterial, but it is important that every succeeding tooth should cross its predecessor, or be intermediate to the two before it, as, if the teeth followed one another

in right lines, they would produce furrows in the work, and not comparatively smooth surfaces.

In cutting files and rasps, they always become more or less bent, and there would be danger of breaking them if they were set straight while cold; they are consequently straightened while they are at the red heat. Previously to their being hardened the files are drawn through beer grounds, yeast, or other sticky matter, and then through common salt mixed with cow's hoof, previously roasted and pounded, which serves as a defence to protect the delicate teeth of the file from the direct action of the fire. The compound likewise serves as an index to the temperature, as on the fusion of the salt the hardening heat is obtained; the defence also lessens the disposition of the files to crack on being immersed in the water.

The file, after being smeared over as above, is gradually heated to a dull red, and then straightened with a leaden hammer on two small blocks, also of lead; the temperature of the file is afterwards increased until the salt on its surface just fuses, when the file is immediately dipped in water. The file is immersed quickly or slowly, vertically or obliquely, according to its form, that mode being adopted for each variety of file which is considered best calculated to keep it straight. It is well known that, from the unsymmetrical section of the half round file, it is disposed on being immersed to become hollow or bowed on the convex side, and this tendency is compensated by curving the file while soft in a nearly equal degree in the reverse direction. It nevertheless commonly happens that, with every precaution, the file becomes more or less bent in hardening, and, if so, it is straightened by pressure, either before it is quite cold, or else after it has been partially reheated. The pressure is variously applied, sometimes by passing one end of the file under a hook, supporting the centre on a prop of lead, and bearing down the

opposite end of the file, at other times by using a support at each end and by applying pressure in the middle by means of a lever, the end of which is hooked in the bench. Large files are always straightened before they are quite cooled, after the hardening, and while the central part retains a considerable degree of heat. When straightened, the file is cooled in oil, which saves the teeth from becoming rusty.

The tangs are now softened to prevent their fracture. This is done either by grasping the tang in a pair of heated tongs, or by means of a bath of lead contained in an iron vessel, with a perforated cover, through the holes in which the tangs are immersed in the melted lead, which is heated to the proper degree. The tang is afterwards cooled in oil, and when the file has been wiped and the teeth brushed clean, it is considered fit for use. The superiority of the file will be found to depend on four points—the primary excellence of the steel, the proper forging and annealing without excess of heat, the correct formation of the teeth, and the success of the hardening.

To choose a good file, hold it between your eye and the light, point towards you, and you can see the cutting edges of every tooth. See if they are all clean, smooth and sharp. If notched, cracked, uneven and irregular, they indicate a poor file. Look all over for fire-cracks, hold up to the light as before, but reverse the ends and see if the file is all one colour. If it shows a chequered appearance, it is uneven in temper, hard and soft in spots. Strike the file with some hard substance. If there are any flaws in it, the ring of the steel will betray them.

Filing is an operation that mechanics frequently require to practise. Whenever the use of the file can be avoided, by the use of the lathe, the milling machine, or the planer, it is certainly desirable. Considerable skill is required to smooth surfaces of large area by means of files alone, more especially when these surfaces are required to be accurately flat. The

method of preparing surface plates, as detailed by Sir Joseph Whitworth, is most valuable information to anyone desirous of excelling in this particular branch of practical handicraft. In engineering works, filing is superseded by the planing and shaping machines for almost all work of large size. The speed and accuracy of the planing machine cannot be approached by the file when there is a great quantity of material to be removed. Files are then only used for the purpose of "fitting," and to smooth up those parts which are inaccessible to the planing tool. A planing machine is one of those expensive and heavy pieces of machinery frequently beyond the reach of mechanics, and it therefore becomes necessary to learn how to dispense with its valuable aid.

Cast iron usually forms the bulk of the material used by engineers, and this is the metal on which we will proceed, metaphorically, to operate. The hard outside skin on cast iron, and the sand adhering to its surface, make it somewhat formidable to attack. If a new file is used for the purpose, it will be assuredly spoiled, and to no purpose. One which has been very nearly worn out will be nearly as effective, and will not be much deteriorated by the use to which it is put. There are several ways of removing the "skin." One is to "pickle" the casting, that is, immerse it in a bath of sulphuric acid and water for a couple of days. This will dissolve the outer crust of the casting, and liberate the sand adhering to the surface Another plan is to remove a layer of the casting from that part which has to be filed by means of a chipping chisel. This is a very good plan where much material has to be removed from some particular part of a large, unwieldy piece of machinery, though some practice will be required with the hammer and chisel before they can be used satisfactorily.

The art of filing a flat surface is not to be learned without considerable workshop practice. The file must be used with

long, slow and steady strokes, taken right from point to tang, moderate pressure being brought to bear during the forward stroke. The file must be relieved of all pressure during the return stroke, otherwise the teeth will be liable to be broken off, just in the same manner that the point of a turning tool would be broken if the lathe were turned the wrong way. It is not necessary to lift the file altogether off the work, but it should only have its bare weight pressing during the back stroke. One of the chief difficulties in filing flat is that the arms have a tendency to move in arcs from the joints, but this will be conquered by practice. Work which has been filed up properly will present a flat, even surface, with the file marks running in straight parallel lines. Each stroke of the file will have been made to obtain a like end, whereas work which has been turned out by a careless or inexperienced workman will often bear evidence that each stroke of the file was made without any regard to any others, and the surface will be made up of an unlimited number of facets, varying in size, shape and position. Those who have never received any practical instruction in the use of files generally have a bad habit of pressing heavily on the tool continuously, during both forward and backward stroke, and at the same time work far too quickly. These habits, combined, will almost invariably spoil whatever is operated on, producing surfaces more or less rounding, but never flat.

The position of the vice at which we are to operate is a most important point to be decided before commencing our filing proper. The vice should be fixed at the correct height, and so that the work held in the jaws will lie level. As to what is really the correct height, some slight difference of opinion exists. This is, probably, owing to the fact that the height of people varies. For filing general work the top of the vice jaws should be placed so as to be level with the

elbow of the workman, which will be found to range from 40in. to 44in. from the floor; therefore 42in. may be considered as an average height best suited for all heights of workmen, when the vice is to be permanently fixed. If the work to be filed is small and delicate, requiring simply a movement of the arms, or right hand and arm alone, the vice should be higher, not only in order that the workman may more closely scrutinise the work, but that he may be able to stand more erect. If the work to be filed is heavy and massive, requiring great muscular effort, its surface should be below the elbow-joint, as the operator stands further from his work, with his feet separated from 10in. to 30in., and his knees somewhat bent, thus lowering his stature; besides, in this class of work it is desirable to throw the weight of the body upon the file, to make it penetrate, and thus, with a comparative fixedness of the arms, depend largely upon the momentum of the body to drive the file. It will, therefore, be seen that in fixing the height of the vice, the nature of the work and the stature of the operator should be considered, if it is deemed necessary to apply the principle correctly. Having the vice fixed properly, the correct position to assume, when filing, is the next consideration. The left foot should be about 6in. to left and 6in. to "front" of the vice leg; the right foot being about 30in. to front, that is to say, 30in. away from the board in a straight line with the vice post. This position gives command over the work, or, rather, over the tool, and is at once characteristic of a good vice-man. The file must be grasped firmly in the right hand, by the handle.

When the object is to remove a mass of metal, the file requires to be as large as can be conveniently handled upon the work, and this for machinists' use need not, for the largest work, exceed a 20in. file, which, to make it bite well and drive a fair cut, will require all the power a man can exert continu-

ously. The cut of the file should be, for roughing wrought iron, a bastard cut; for steel, a second cut; and for brass, a rough file. To obtain the greatest amount of duty, the file, if a large one, requires applying on the forward stroke with all the power the operator can put on it; while, if a small one, with as much power as can be without danger of breaking the file. The end of the file handle should abut against the palm of the hand, so that the file is pushed, and not dragged. The work should be about as high as the operator's elbow, and for full duty with, say, a 14in. file, the left foot should be near the front of the vice, while the right one stands at least 26in. behind. The left hand must just hold the point of the file lightly, so as to guide it, and, when taking the forward cut, a fairly heavy pressure must be applied, proportionate to the size of the tool in use and the work being done.

On the forward stroke the front foot should be almost entirely relieved of the operator's weight, which will fall on the file, while on the back stroke the front foot should take most of the weight, so that the file may be relieved. The file strokes should not all be made parallel one to another, but first at one angle and then at another, so that the file marks will cross and recross each other, which enables the tool to cut easier. The speed of the file may be as quick as it can be pushed, providing the file is pressed to the work with all the weight possible, or if a small one, with all its strength will stand.

For filing to shape a smaller file must be used, so that even while removing the mass of the metal, the shape of the work can be readily observed by a slight lateral motion of the file, without entirely removing it from the work, or without stopping the file strokes. In filing to fit lies the greatest art of filing, for here it is necessary that the file be of true outline, and to be so applied that it touches the work at the required spot only.

It is as well here to make a few remarks on handles; they should always be proportionate to the files to which they are fitted. The hole in the handle should be properly squared out, to fit the "tang," by means of a small "float," made from a small bar of steel, similar to those used by plane-makers and cabinet-makers. The handles should always have good, strong ferrules on them, and the files should be driven home quite straight and firm, so that there is no chance of the tool coming out. Each tool should have its handle permanently fixed; it is very false economy to be continually changing, considering the low price of handles.

The operation of filing a casting just home from the foundry should be preceded by thoroughly brushing the casting with a hard brush, so as to remove all the loose sand. Then take an old file and file away steadily at the skin till you come to a surface of pure metal. Having by then removed those parts which spoil files, the old file, with which but slow progress is made, can be changed for a better one. The best as well as the most economical will be one which has been used for filing brass till it has become too much worn for that material. Such a file is in first-class condition for working on cast iron after its sandy skin has been removed, and when worn out on that it will serve first-rate for steel.

When it is necessary to file up a small surface—say 2in. or 3in. square—the file must be applied in continually changing directions, not always at right angles to chops of the vice. In that case, though the work might be made perfectly straight in that direction, yet there would not be any means of assuring a like result on the part lying parallel to the jaws. When the surface is fairly flat, the file should be applied diagonally both ways; thus any hollow or high places, otherwise unobservable, will be at once seen, without the aid of straight edges. This

method of crossing the file cuts from corner to corner is recommended in all cases. The file should invariably travel right across the work, using the whole length of the file, not just an inch or so at some part, as is too often the case. When in use the file must be held quite firmly, yet not too rigid, so that the operator cannot feel the work as it progresses. The sense of touch is brought into use to a far greater extent than the inexperienced would imagine, and a firm grasp of the tool, at the same time preserving a light touch to feel the work, is an essential qualification for a good filer.

In filing out mouldings and grooves which have sections resembling, more or less, arcs of a circle, a special mode of handling the file becomes requisite. The files used are generally rats'-tails or half rounds. These are not used with the straightforward stroke so necessary in using the ordinary hand files, but a partial rotary motion—a sort of twist axially —is given to the file at each stroke. This screwlike motion, given alternately from right to left, and *vice versâ*, serves to cross the file cuts and regulates the truth of the hollow.

Files which have become clogged with minute particles of metal, dirt and grease are not fit to use, and the following directions will enable anyone to keep them in proper order. The most generally used tool for cleaning files is the scratch brush; but this is not very efficient in removing those little pieces of hard metal which get firmly embedded and play havoc with the work. File cards are also used; they are made by fixing a quantity of cards—such as a pack of playing cards—together by riveting, or by screwing to a piece of wood. These file cards are used in the same way as the scratch brushes—transversely across the file in the direction of its cuts—and though neither tool produces much effect yet both are often used.

When files have been clogged with oil and grease, the best

plan is to boil them for a few minutes in some strong soda water; this will dissolve the grease and, as a rule, set most of the dirt and filings free. A little scrubbing with an old tooth brush will be beneficial before rinsing the files in boiling water and drying them before the fire. These methods will prove effective in removing ordinary accumulations of dirt, but those "pins" which are so much to be dreaded when finishing work can only be removed by being picked out with a scriber point, or, what is better, a piece of thin, very hard, sheet brass, by means of which they can be pushed out very easily. These "pins" may be to a certain extent avoided by using chalk on the file, if it is used dry, or a drop or two of oil will sometimes help matters.

With regard to finishing filed work, such as has to be made particularly presentable to the eye, there are many ways of polishing and burnishing, but, properly speaking, these are not filing. Nothing can exceed the beauty of well-finished work, perfectly square and smooth as left by the file, untouched by any polishing materials. In such work the filing must be got gradually smoother by using files of finer cut. When the work is deemed sufficiently finely finished for the purpose, the lines should be carefully equalised by "draw filing." For this the file is held in both hands, in a manner similar to a spoke-shave, and drawn over the work in the same way, producing a series of fine parallel lines, the beauty of which it would be difficult to exceed for the purpose of high-class engineering work.

CHAPTER VII.

TOOL GRINDING.

MECHANICAL operations are most successfully carried out with the most suitable tools. Edge-tools are employed in many mechanical operations; keen edges, properly shaped, always give the best results, so that all those who employ edge-tools will find tool-grinding a subject deserving close study. A cutting edge is formed by the line of junction of the two facets of a wedge. The angle of these two facets one to the other is determined by considerations of strength or of shape. As a rule, the harder the material to be cut the more the approach of the two facets to a right angle, one with the other; and so likewise the greater the strength required, the nearer the facets to a right angle. Thus, while the facets of a graver may stand at an angle of 50°, those of the cutters for a pair of shears or a punching machine will stand at an angle of about 85°, though both may be used to cut iron and steel. In this latter case, the strength being the main consideration, it must be obtained at a sacrifice of keenness, whereas, if we take the case of a razor or a lance, sharpness is the main consideration, and strength is disregarded. There are, however, certain considerations in the production of the cutting edge itself, regardless of the angles of the facet, which affect all cutting edges, and these considerations we propose to discuss. Grindstones of various sizes, forms and textures are employed for grinding and shaping edge-tools.

A flat circular disc of sandstone or sandstone grit has been

used for sharpening in generations past. The ancient warrior put an edge to his bronze spear-head by the means employed by the modern cutler to give the keen edge to a razor.

Probably no workshop tool pays better for the care bestowed upon it, or affects the work of an entire factory more than the grindstone. It is, however, almost an exceptional occurrence to find a good stone, properly hung, running true and in perfect order. The workshop stone generally has a trough beneath it to hold the water. Being left with a portion of its edge immersed, that part becomes softened, and the stone wears unevenly. The out-of-doors grindstone soon becomes a worthless wreck from the effects of the weather; the sun's rays warping the wooden frame, and making the stone itself too hard for use.

Although the applications of a grindstone are limited, still, in its sphere it acts to perfection. No machine or process has yet been devised to supersede the grindstone, and improvement has added but little to this primitive tool. Science has produced artificial compounds which take the place of the original natural stone; and they are often used advantageously. They are, however, new only in the method of manufacture. Emery compounds are now used very extensively for all purposes of grinding, and they have many advantages over the natural stones. Probably the employment of emery grinders will become universal at an early date. Even now they are fast displacing natural stones in Government workshops and other large factories where economy is studied.

Every employer of edge-tools should endeavour to get a grindstone that will do its allotted work well, and in the quickest time. A good grindstone, to replace one that is hard and flinty, is always a paying investment. A writer on the economic conduct of workshops recommends that a bad stone should be immediately broken up as the best means of saving time

and trouble, besides earning the thanks of those who would otherwise have to use it. Only those who have used a good stone, properly mounted, with its edge running perfectly true, can appreciate the true worth of a grindstone. Those who have used only lumpy, badly-kept stones cannot form a just estimate of the value of grindstones, as applied to the production of the edges of hardened steel tools. The requisites of a good grindstone are uniformity of texture, a keen bite, freedom from cracks and flaw, and sufficient cohesion to hold together and withstand the enormous centrifugal force to which it is often subjected. Newcastle stones are widely known and excellent. They vary in their texture, and coarse or fine grit may be chosen as desired. Artificial stones are made by binding together silicious particles with silicate of lime.

The grindstone for general purposes should be at least eighteen inches in diameter, though two feet is a better size. It is then large enough to form its own fly-wheel, the stone being mounted in a frame of its own. A treadle is far preferable to a hand-winch for turning the stone, as the latter generally necessitates the services of two persons to grind. Even the most simple tool, as a rule, requires the use of both hands to guide it on the stone. When an attempt is made to turn the winch by one hand, and hold the tool by the other, unsatisfactory results are obtained.

The speed at which grindstones are driven in some cases amounts to a surface velocity of three or four miles per minute, but to attain such a speed it is of course necessary to employ multiplying gear and steam power. For ordinary tool grinding sufficient speed is got by turning a two-foot stone as fast as convenient by a treadle, but when a hand crank is used the stone goes far too slow, and the remnants of a worn out grindstone only a foot or so in diameter, sometimes to be seen in use turned with a handle of that radius, are quite unfit for any use-

ful purpose. By putting a fly-wheel on the spindle and driving at a good speed, such a stone might be of some use, but the trouble it would involve is not worth the saving in a new stone.

Ransome's patent free-grit stones, made by the method previously mentioned, are asserted to have a tensile strength of about six hundred pounds per square inch, and the best results are attained with a surface velocity of from 2,000 to 4,000 feet per minute.

When tools are ground the operation should always be conducted on scientific principles, so as to produce the best results. The application of the tool to the work must also be correct. A properly shaped tool, improperly applied, will probably not be more effective than one applied on correct principles, having a badly formed edge. Well-ground tools, properly applied, are the essentials of economic workshop practice.

First comes the question: On which side of a stone a tool should be ground? This depends upon the shape of the tool, the amount of metal requiring to be ground off, and the condition of the grindstone. If the tool is held in such a position that the revolving surface of the stone runs towards the operator, the operation can be performed quicker, and as a rule, better; but it is in many cases quite dangerous, because the edge of the tool is liable to catch in any soft part or a spot in the stone, and to be dragged from the fingers, carrying them with violence down to the rest (every grindstone should be provided with a rest), and rendering them very liable to injury by being caught between the rest and the stone. In determining upon which side of the stone any given tool should be ground, the workman takes into consideration:—The shape of the tool, the amount of metal requiring to be ground off, and the condition of the grindstone.

In ordinary shop parlance, the side of the stone on which the face of the stone enters the trough is always called the side with the stone running to you, because all grinding which requires performing with the stone running to you is performed on that side, and in conjunction with the use of the rest. There is no excuse, and it is very dangerous, to grind on that side of the stone without using the rest as a steadying point and as a safeguard. With the rest, the grinding can be more delicately, truly and accurately, as well as expeditiously performed, because of the extra force with which the tool can be held steadily to the stone.

To true-up a grindstone, firmly fix a rest on the grindstone frame, and use, as a turning tool, a piece of wire about $\frac{1}{8}$in. thick; or, if a large stone, a piece of small iron gas barrel, applied at a slight angle horizontally and pointing downwards. When using, roll the wire over towards the cut, and thus present continually a fresh sharp edge. Hang the water-trough on a joint, and let the water in it be clear of the stone; when it requires wetting lift up the trough. A grindstone will turn best when slightly wetted.

For small tools the Bilstons, quarried in Staffordshire, have an excellent reputation, as they possess the requisite qualities of a fine even grain, without hard patches. Newcastle stones are more widely known, and are excellent; they vary in their texture, and coarse or fine-grained may be chosen as desired. Sheffield stones have a hard coarse grit, and are used principally for rough grinding. Stones of coarse grain and large size are obtained from Yorkshire and Derbyshire, but through the want of cohesion and toughness especial care is necessary in selecting from these varieties, as they are liable to break up from centrifugal force, accidents of a most serious nature generally resulting from such mishaps.

Artificial grindstones (compounded as already stated) are

made in moulds, so that they are turned out perfectly true, circular and flat; there are no pebbles, hard spots, coal flaws, clay seams, or like defects incidental to natural stone. The process of manufacture is this: Silicate of soda, which is a kind of water glass, is first made by dissolving flints with caustic alkali. Silicious sand of fine and even grain is then mixed with the plastic mass, and the whole is moulded to the proper shape. In some cases the stone is treated chemically to render it hard; hydraulic pressure is employed to solidify the material. Some stones acquire their hardness by simple exposure to the atmosphere. According to the fineness of the grains of sand used the texture of the stone is modified, and emery may be used in its stead, resulting in a grindstone of exceptionally good quality; and these artificial stones are in many cases cheaper than the natural stone to quarry and shape, which necessitates the expenditure of considerable time, sometimes with a useless result.

Other kinds of artificial stones have been made in which the grit is held together by various hard-setting cements, but those resulting in a plaster-like surface are of little use, lacking as they do the sharp cutting properties of the natural stone. Emery and sand are mixed with various substances with a view to obtaining a useful whetstone; clay is used in a plastic state, and then baked with the cutting material incorporated in it; shellac and similar substances have the admixture made whilst they are liquefied by heat.

The following receipts for artificial grindstones are from an authentic source: Melt one part of shellac and add to it three times the quantity of washed silicious sand; emery may be used instead of sand. Boiled linseed oil is said to form an all sufficient agglutinant, and merely requires to be subjected to the influence of the air after the abrading material has been mixed with it. When the mass approaches solidity it is

subjected to pressure in moulds and finally hardened by heating. It would be impossible to give a list of the numberless formulæ which have been tried with varying success in the manufacture of emery wheels, which have now taken a very prominent place in tool grinding.

Glazing wheels are made of wood, covered with leather charged with emery, and are used by cutlers, especially for grinding and sharpening knives, tools, etc. They are also used for levelling and surfacing many metallic articles, for removing the scale from castings, and for trimming small castings such as builder's hardware. A wooden wheel without any leather covering is used by lapidaries in smoothing soft and rounded stones. These wheels are fed with flour-emery and water. Glass-cutters employ similar wheels, with pumice-stone and water, for smoothing, and with putty-powder and water for polishing. These wheels, commonly called glazers, are made of wooden discs built in quadrants, so arranged as to present the end of the grain on the edge. They are fed with emery, and mahogany is said to be a good wood to use. The modern emery wheel would be preferable in many respects.

Laps, made of soft metals, such as lead and copper, are very extensively used for grinding tools of peculiar form. The metal lap is turned to the desired shape, and is then charged with emery, or some other abradent, and oil; the particles become embedded in the surface of the soft metal, and make of it a "grindstone," which preserves the shape originally given to it, and requires to be continually supplied with fresh cutting material in its powdered form. Similarly, discs of wood are used, and to coat the edge of one with glue, and whilst that is yet soft to press emery into it by rolling the disc in some powder, is an expedient for quickly obtaining a substitute for a grindstone, and it answers its purpose for a time.

The natural grindstone is, however, the one which generally does duty in the mechanic's workshop, and to this one we wish to direct our attention especially. Small stones may be bought complete and ready for use, fitted in a cast-iron frame, forming at the same time its water trough. They are also used on a spindle, and driven between the lathe centres, but this is a practice to be most emphatically condemned.

The first cost of a grindstone is but a trifling consideration, when the long time that it will last and the amount of work that it will do are reckoned; and thus it is well to select as good a stone as can be got, as the extra cost, if any, will be amply repaid in the time saved in producing a like, and generally a better, effect with the superior stone. Grindstones mounted on frames, turned true on the edge and ready for use, are sold by most ironmongers at prices varying from about 25*s*. for a 24 in. stone; and the plain, unmounted, rough circular stone of that diameter costs from about 7*s*. 6*d*., according to the thickness, the cost of conveyance from the quarries, and the rate of profit charged by the seller. Such a grindstone will answer all the requirements of engineers, carpenters and others, and will be found equal to most of the tool-grinding that is likely to be done in a small workshop.

We now proceed to the processes of grinding performed after tools have been sharpened on the grindstone. By means of hones of fine grit a keener edge may be produced.

Hones or oilstones are usually of some slaty stone. They are obtained from the varieties of metamorphic schists, which are sufficiently compact, and in which the particles of quartz are extremely minute and regularly disseminated, thereby giving them a fine and uniform texture. This texture, and also the hardness of the stone, differs considerably in the various kinds employed. A good stone is often thrown away as worthless when the trouble is that it is merely oil-soaked. If

this is the case, lay it in benzine to soak from one to three days, until the old oil is eaten out; then on using it to polish again, with fresh oil, it will be found as good as new.

Instead of oil, which thickens and makes the stones dirty, a mixture of glycerine and alcohol is used by many. The proportions of the mixture vary according to the instrument operated upon. An article with a large surface—a razor, for instance, sharpens best with a limpid liquid, as three parts of glycerine to one of alcohol. For a graving tool, which is very small, employ glycerine almost pure, with but two or three drops of alcohol.

Turkey oilstones, which are obtained from the interior of Asia Minor, are in very general use for imparting a fine edge to every kind of edge tool used by workers in both wood and metal. This stone is of very fine grain. As a whetstone it surpasses every other known substance, and possesses, in an eminent degree, the property of abrading the hardest steel. It is, at the same time, of so compact and close a nature as to resist the pressure necessary for sharpening a graver or other small instrument of that description. Little more is known of its natural history than that it is found in the interior of Asia Minor, and brought down to Smyrna for sale. The white and black varieties of Turkey oilstone differ but little in their general characters. The black is somewhat harder, and is imported in larger pieces than the white. It is often cracked and flawed, and for this reason is generally cemented to a slab of slate, or sometimes embedded in wood. Sir Thomas Gresham paved the old Royal Exchange with Turkey stone. In the catalogue of a large Sheffield firm it is now priced at fifteen pence a pound.

Arkansas stone, imported from North America, is perhaps the finest variety of oilstone to be found in the market; its high price—about five shillings a pound—being the chief bar

to its general introduction. It is a fine white stone, composed of upwards of 99·5 per cent. of silica, rather brittle, and having an excellent bite. Stones of this kind, and other expensive varieties, are used as thin slabs, mounted on a backing of inferior value. Also as small slips sometimes, about the size of a goose-quill.

Ouachita (or Washita) stone somewhat resembles the last-named, but is of a coarser grain. The price is about eighteenpence to two shillings a pound. It is quarried in blocks of from two to four feet square, often of irregular shape, which are then split and shaped into oblong slabs. This stone comes from the same quarries as the preceding variety.

A cheap and excellent stone for general purposes is called Nova Scotia oilstone, and nearly resembles the Washita or Ouachita stone already spoken of, the price being about one-third.

Norway ragstones are adapted for rapid grinding, they being the coarsest variety of hone slates. Scotland and Russia also furnish ragstones, which are merely highly silicious tough portions of mica schist, obtained from the metamorphic or crystallised schists.

Snakestone and water-of-Ayr stone are used principally with water, and are of a decidedly slaty nature. A hone now widely known as the Tam O' Shanter, and manufactured by Mr. Montgomerie, of Dalmore, Ayrshire, is obtainable at most tool dealers'. These stones have stood the test of years, and are highly approved by practical men. The Tam O' Shanter hone is made in several grades of grit. All the stones previously spoken of may be used dry or lubricated with oil or water.

Amongst other varieties of stone possessing useful qualities may be named Charnwood Forest stone, quarried in Leicester-

shire, and forming a strong, useful hone; Welsh slate, a tough, fine-grained slate of rather unequal texture; Hindostan stone appears to be not so well known in commercial circles, though it is an excellent stone, and sells at a moderate price; German razor hones, imported from the slate mountains in the neighbourhood of Ratisbon, on the left bank of the Rhine, sometimes cut in thin slabs, which are cemented to slate, though sometimes the combination is natural.

Used dry the hone soon becomes filled with particles of the abraded metal, and ceases to cut satisfactorily. Water will to an extent obviate this, and it has the advantage of cleanliness and costlessness. Oil gives a finer cut, and has almost universally superseded water in every trade. The edge produced is finer, and the liability to rust is removed.

The hone used for tool grinding, whatever may be its kind, should be of perfectly even texture. Hard and soft places will be a source of continual annoyance, and will tend much to mar the success of the operation. In any case, oilstones will wear irregularly, and it is necessary to occasionally re-grind them flat. Wide chisels, plane irons, and such tools cannot be ground on a rugged stone, and in every case a flat surface will produce the best results.

There are several ways of levelling a stone. It should first be wiped dry, and be as free from oil as possible. The grinding may be done with sand on a flat stone slab, or on a sheet of coarse emery paper laid on a flat board. It is sometimes convenient to grind the oilstone against the side of the ordinary shop grindstone. This, or any of the methods here given, will be found effective.

The keen edge which is to be produced by means of the oilstone can only be ensured on a tool which has been previously properly ground on a grindstone. The bevel produced by

that means has simply to be ground on the oilstone at its extreme end, so that a much smaller facet, at a slightly greater angle, is made on the bevel. There is considerable art in the manipulation of tools on the oilstone to produce the desired result. The wire edge left from the grindstone has to be reduced, by grinding, till it finally breaks off; then a few more strokes of the tool on the stone will make the edge perfect. The flat side of the tool, forming the edge opposed to the bevel, is generally gently applied to the oilstone to remove any trace of a wire edge on that side.

The process of sharpening a chisel on the oilstone will serve as a guide to the method pursued for many other tools. The stone, which has been wiped quite clean, and having a flat surface, is laid upon the bench with one end toward the operator, and a few drops of olive oil are placed upon it. The chisel, held by the handle with the right hand, and steadied with the fingers of the left grasping its blade, is placed on the stone, bevel downwards, somewhat slanting towards the breast. A few strokes, taken the entire length of the stone, will distribute the oil upon it evenly, and also enable the operator to notice the correct angle at which to hold the tool whilst sharpening. The motion given to the chisel must be parallel to the top of the stone, and this is somewhat difficult for an unpractised hand. The hands have a tendency to place the chisel more upright at the further end of the stroke, and to depress the handle as it is drawn nearer to the breast.

If a wide chisel is placed on the stone with its blade edgeways towards the operator, and in that position worked back and to by the hands, as though sharpening, the faculty of moving parallel to the stone will be rapidly acquired. This done, a straight flat facet may be ground on any tool, no matter how thin its edge may be. It is frequently conducive

to producing a good edge if the tool be moved on the stone in small circles, the position and size of which are continually varied. The small bevel made on the oilstone should be equally as flat as the large one. A rounding facet is not only indicative of bad workmanship on the part of the sharpener, but also has a detrimental effect on the cutting powers of the tool.

In many of the smaller tools used in the mechanical arts it is highly advantageous to have duplicate cutting edges precisely alike in every respect. In some tools this is essential, and in a few it is necessary to re-grind them, so that the new cutting edge is precisely like the former one. Various forms of fancy drills and cutters used for ornamental purposes, also those used for producing the barleycorn engine-turned pattern on the backs of watch cases, may be cited as examples of these latter tools.

An apparatus is specially designed for this purpose. It is called a goniometer. The same name is applied to an instrument used for measuring the solid angles of crystals, etc., but the goniometer used in tool grinding consists of a receptacle in which the tool to be operated upon may be fixed. This receptacle is jointed to a frame in a manner that it may be swung over on either side, and also slanted backwards as much as required, the amount of each motion being duly registered on graduated arcs. The instrument rests upon two legs, and when in use the point of the tool fixed in it forms a third, so that each is always in contact with a flat surface, the tool resting on the face of a hone, the two legs on a surface level with it, but not abrasive. The entire goniometer is then moved in a circular direction, rubbing the surface, and by this means the point of the tool is ground perfectly flat. Whilst the legs are kept upon the surface it would be impossible to grind otherwise than flat. When an angular-pointed tool is

ground by the aid of this tool one angle is first operated upon, then the tool receptacle is swung over to a position exactly corresponding on the other side, and thus the second angle is made precisely similar to the first. Tools of similar construction are used for many analogous purposes. Watchmakers use them to hold various steel pieces whilst polishing, so that they may be perfectly flat. Inexperienced hands, or those who from some cause fail to produce a level facet on the end of a graver, frequently improvise a rough form of goniometer, using a block of wood split to the right angle required, to which the graver is fixed with a simple metal clip held with a wood screw. Such a makeshift contrivance may be made in a few minutes, and its use will for ever remedy the unworkmanlike rounding faced tools now sometimes seen.

A plane iron may be judiciously set finally for accurate work by wedging it in such a position that it projects somewhat less than an eighth of an inch from the sole of the plane stock, and then carefully oilstoning the edge with the end of the stone resting on the wood. It is advisable to cover this latter with a sheet of paper, or to take some other precaution to prevent the oil and dirt usually found on an oilstone soiling the plane and subsequently the work.

There are special forms of grinders used for sharpening moulding tools, and others of peculiar, irregular, and special forms, which are not more conveniently ground from the top Hollow beading tools used to shape a half-round moulding—sometimes in a plane stock, at others in a handle used as a turning tool—are ground on a conical grinder, the diameter of which corresponds with the radius of the hollow, the amount of taper being sufficient to give the necessary clearance to the cutting edge. These grinders are usually made of metal—lead, iron, brass and others being employed. The cutting material is applied together with the oil, and adheres

to the grinder, into which it is subsequently embedded by the tool laid upon it.

Thus far a general insight into the method of grinding small edge tools has been given, and the subject is an important one to all who use edge tools. It has been truly said that a well-sharpened tool is not only typical of good workmen, but also goes a long way towards producing good work.

The ultimate result of tool-grinding is to produce a sharp cutting edge, and this will be fine according to the fineness of the stone on which the tool is ground. Rough grinding is suited to heavy edge tools, and light edge tools require finer abradents. All grinding, however fine, leaves a serrated edge, which will correspond with the texture of the stone on which the grinding was done. As a coarse-toothed rip saw is unsuited to cut hard wood across the grain, so will a coarsely-ground edge tool be misapplied on fine work. To sharpen a meat-axe on a fine oilstone would be labour wasted, whilst to use a razor which has not the keenest edge possible would be labour in vain. The art of tool-grinding depends much for its success on the judicious selection of the grindstones or hones employed, so that the edge produced may be suited to the purpose to which it is to be applied.

No mechanical operation can appear to be more simple than that of grinding a tool to a cutting edge, and very few persons have any idea of the large amount of knowledge as well as skill that may be displayed in simply sharpening a tool. To give a tool a suitable cutting edge, one must understand the nature of the material to be cut, and must have had some experience in cutting it, so as to know what variation to make in the tool to suit the variations in texture, closeness of grain, hardness, etc. The axe, sword, chisel, knife, and needle, each require whetting to suit their special purpose.

In a succeeding chapter, information will be furnished on the various abrasive and finishing processes with which the worker in metal needs to be acquainted; and much that has been said in the present chapter in relation to the grinding of tools will be found of useful application in dealing with the material and appliances which are involved in those processes.

CHAPTER VIII.

DRILLS AND DRILLING.

DURING the last thirty years many attempts have been made to introduce a better system of drills and drilling, and on this subject very much might be written. Mr. Ford Smith, the Manchester engineer, read an interesting paper on the subject before the Institute of Mechanical Engineers. That paper contains numerous practical details of actual work, which, together with the remarks elicited in the discussion which followed, are mostly incorporated with this chapter.

Many engineers have used square bar-steel, which the blacksmith has twisted and then flattened at one end to form a drill. The object of the twisted stem was to screw the cuttings out of the hole; and to some extent this succeeded, but not perfectly. The twisted square section revolving in the round hole had a tendency to crush or grind up the cuttings; and if they were once reduced to powder, it was difficult (especially in drilling vertically) for the drill to lift the powdered metal out of the hole. In most cases, the lips of these drills were of such form that the cutting angle or face of each lip, which ought to have been about 60°, was 90°, or even still more obtuse; this being an angle which would scrape only, and could hardly be expected to cut sweetly or rapidly.

Again, there were attempts to make the cutting angles of the two lips of much the same number of degrees as that given by the twist itself in a good twist drill. This was done by forging or filing a semicircular or curved groove on the

lower face of each lip. For a short time, lips thus formed cut fairly well, but a very small amount of re-grinding soon put them out of shape and made them of such obtuse cutting angles that good results could no longer be expected from them; and to be constantly sending such drills to the smith, and then to the fitter, to file into form again before they were re-hardened, was found to be too tedious and too expensive.

Again, to arrive at the best results in drilling, each of the cutting lips should make the same angle with a central line taken through the body of the drill; in other words, the angles should each have exactly the same number of degrees, say 60°. The clearance angles also should be identical, and the leading point should form the exact centre point of the drill.

From practice, it is found that if these proportions are not correct, the drill cannot pierce the metal it is drilling at more than about half the proper speed, and the hole produced will also be larger than the drill itself, as will be exemplified a little later on.

For some purposes, the flat drill—if properly made, with the same care and precision as were expended in making twist drills—may be superior. Hitherto, one of the great advantages of the twist drill had been that so much care and pains had been expended in making it; but using flat drills, and taking the same amount of care to ensure the sides being parallel and the angles cut even, and also pointing the edge truly, so as to do away with the blunt nose, the drill would work freely, and the shavings come off as from the twist drill. Such work can be done by a flat drill, which was machined all over and finished with great care, thus costing probably quite as much as a twist drill could be purchased for. All parts of the drill were made true and concentric; and it would therefore be practicable to grind the cutting lips by machine so accurately, and to flute the cutting angles of

the lips so accurately, as to produce excellent cutting results for the short space of time the two flutes would keep in order. But when the drill was worn, say half an inch shorter, the proper angles for cutting would be found no longer existing; and to restore them, a quarter of an inch of the length of the drill would have to be ground to waste, before two new flutes could be again ground into the lips, so as to restore the proper cutting angles. Or, worse still, where the flutes could not be ground in mechanically, the drill would have to be heated to soften it. Immediately this was resorted to, the finished accuracy of the drill was more or less destroyed; whereas in a good twist drill, used with care and re-ground mechanically, the cutting angles remained the same, however short the drill might be ground. This, coupled with the fact that the wear took place only at the end of the drill, and that the drill was hardened its whole length, produced the result that softening never had to be resorted to; the grinding or shortening of the drill was exceedingly slow; and there being no waste or expense in repairs, the cost of the twist drill, spread over its lifetime, was exceedingly small.

A flat drill, used in drilling through cast steel, about 11 in. deep, would bring shavings out, on either side of the drill, from 10 to 12 in. long, or even more; and a twist drill would not do much more than accomplish that. There was this difference between the plain drill and the twist drill, that in forming the latter, a great quantity of material was sacrificed in cutting out the groove, and it was a more expensive tool to get up. In the flat drill there was little waste of material, and it could be drawn down when it got too short; whereas, when a twist drill got too short, it became valueless. In going through bad castings, no doubt the twist drill would make a straighter hole.

Many trials have been made from time to time with ½ in.

drills of ordinary form manufactured by different engineers who had wished to see the effect of working a common flat drill against a twist drill. The result has been that if a feed were put on the common drill, approaching that used for the same size of twist drill, the former was invariably fractured, while the twist drill escaped fracture. The feed used was often so heavy that the spindle of the drilling machine could be observed visibly descending. Drilling machines originally provided with self-acting feeds, as coarse as could safely be applied for feeding forward the common drill, had been found to accomplish so much more work with the twist drill in a given time; all the feeds having been increased by about 90 per cent.

A common drill may "run," as it is usually termed, and so produce a hole which is anything but straight. This means that the point of the drill will run away from the denser parts of the metal it is cutting, and penetrate into the opposite side, which is soft or spongy. This is especially the case in castings, where, for instance, a boss may be quite sound on the one side, while on the other a mass of metal may be full of blow-holes, or so drawn away by contraction in cooling as to be very soft and porous. In such cases it is not possible to prevent a common drill from running into the soft side. This sort of imperfect hole is most trying to the fitter or erector, and if it has to be tapped to receive a screwed bolt or stud, is most destructive to steel taps. The taps are very liable to be broken, and an immense loss of time may also take place in attempting to tap the hole square with the planed face. A twist drill, from its construction, is bound to penetrate truly, and to produce holes which are as perfect as it is possible to make them.

The difficulty of boring with a large drill which had a thick point was by many engineers overcome by first drilling a small

leading hole, and afterwards opening it out to the required size by using a large drill, the point of which, entering into the small hole, had no cutting to perform. There were two objections to that plan; the first being that the point of the larger drill, not having any metal before it to support or steady it, was free to run eccentrically, oscillate transversely, and revolve with a series of jerks, thus producing a badly-finished hole, which, upon examination, would be found to be much jarred, and anything but round. The second objection was, that it was too tedious and expensive to drill a small leading hole first, as a considerable amount of time would be occupied in changing the speed of the drilling machine from the slow speed, which had last been used for the larger drill, to a speed quick enough for drilling advantageously the smaller or leading hole. The change of speed entailed the altering of the strap on the cones of the drilling machine, and in many cases the disengaging and again engaging of the double gearing of the machine. Both these objections were surmounted by using a twist drill. If preferred, its point might be thinned down, in a grinding machine with small emery-wheel, to any degree of thinness which might be found best for penetrating without fracturing; this was a simple mode of reducing the blunt end between the two grooves to any extent. By this system the point only needed to be thinned after about every sixth time the lips were re-ground; of course, each re-grinding of the lips gradually caused the point to become thicker, until it was found advisable to reduce it again by grinding. With this system very heavy feeds might be employed, and a twist drill 2in. diameter had drilled one inch deep in wrought iron for every 62 revolutions; such a feed, however, may be considered too heavy for every-day practice, and a feed of 100 revolutions per inch for drills over $\frac{1}{2}$in. diameter may be preferred.

Flat drills should always be made thick at the shoulders of the drill and coming to a thin edge at the point. Drills used for the last twenty years had been made to that shape; and then there was very little of that forcing the point into the metal. A difficulty in twist drills was that there was in these drills no means of reducing the blunt point between the two grooves, which did not cut at all, but merely squeezed itself into the metal. There must be proportionately much more work concentrated on that little spot than on all the rest of the metal being drilled. It was of more importance in small drills than in large ones; because that blunt point in the smaller drills bore a much larger proportion to the whole area.

There was part of an ordinary flat drill, close to the point, which did not cut at all. If it was looked at from below, there was an oblique line forming the connection of the two ground edges of the drill. That line was not cutting; it merely ran round and rubbed; and that was the part which required all the force on the top of the drill to drive it into the metal. However much the cutting angle of the drill might be improved at the edges, that would not improve the connecting line; hence, in any material, if you had a small core-hole to start with, you could employ at once a feed four times as rapid as you could employ when drilling through a solid piece. However quickly the drill was rotated, it did not give too high a cutting speed at the point; it was too near the centre for that. It was not for the sake of the cutting edges, even if they were not particularly good, that you needed so low a rate of downward feed as one hundred cuts to the inch; but it was for the sake of preserving the point and giving it time to force itself into the metal, that you were obliged to employ fine feeds. The drills revolve with a circumferential speed of about 20ft. per minute, and about 100 revolutions to the inch, of downward traverse—or 200 revolutions to the inch of downward traverse, and cutting

speed of 40ft. per minute, in cases where water could be used.

A new drilling machine, recently made, for dealing with the couplings of propellers, in which the bolt holes were to be drilled out of the solid, each at one operation, showed cuttings which came from a flat drill, 3in. diameter at the rate of $\frac{1}{60}$ in. of feed per revolution, and they were equal to anything that would come from a twist-drill. No doubt one advantage of the twist-drill was the maintenance of shape and size; but the readiness with which the workman could deal with a flat drill would keep it always in the workshop.

Ordinary flat drills should have their cutting ends shaped so that the cutting edges form an angle of from 90° to 120°. The blade of the drill should be about one fifth of its diameter at that part where it is widest, and the point should be thinner down to about one-eighth. The thinner the point the easier will the drill enter. These proportions hold good for drills of about $\frac{1}{2}$in. diameter.

About a quarter of a century ago both the late Sir Joseph Whitworth and the late Mr. Greenwood, of Leeds, made some twist drills; but it is to be presumed that a large amount of success was not achieved with them, as for some reason the system was not persevered with. After that period the Manhattan Firearms Company, in America, produced some beautifully-finished twist drills. Though the workmanship in these was of a superior description, the drills would not endure hardship. It was found that the two lips were too keen in their cutting angles, and that they were too apt to drag themselves into the metal they were cutting, finally to dig in and to jam fast, and to twist themselves into fragments. Mr. Morse then took the matter up, and by diminishing by about 50 per cent. the keenness of the cutting lips of twist drills, made a great success of them. He used the grinding line, and an increasing

twist. In such a drill of the standard length, and before it is worn shorter by grinding, the twist is so rapid towards the lips that the angle they present, or what has been already referred to as the angle of the cutting surface, is very nearly the same as that which had been previously established for cutters' cutting metals.

If the angle of twist is made to increase towards the lips, it will decrease towards the shank. The shorter the drill is worn the more obtuse the cutting angle becomes, and the less freedom will it have, supposing, of course, that the angle, when the drill was new, was the most efficient. Suppose this decrease of twist were carried still further by lengthening the drill, a cutting angle of 90° would eventually be arrived at. The old common style of drill usually has a cutting edge which is so obtuse as not to cut the metal sweetly, but to have more of a tearing action, and thus put so much torsional strain on the drill that fracture is almost certain to take place, even if what would now be considered a moderate feed was put on by the drilling machine.

It is therefore obviously advantageous to adopt from the first the best cutting angle for all twist drills, and to preserve this same angle through the whole length of the twisted part, so that, however short the drill may be worn, it always presents the same angle, and that the most efficient which can be obtained. This cutting angle is easy to fix, and becomes an unalterable standard which will give the best attainable results.

The next important step in twist drills has been to fix a standard shape and angle of clearance for both lips, which should also give the best attainable result. This angle might be tampered with if the re-grinding were done by hand, and too much or too little clearance might easily be imparted to the drill from want of sufficient knowledge on the part of

the workman. If too little clearance, or in some cases none at all, is given to the drill, the cutting lips then cannot reach the metal; consequently they cannot cut. The self-acting feed of the drilling machine keeps crowding on the feed until either the machine or the drill, usually the latter, gives way. Again, if too much clearance is given, the keen edges of the lips dig into the metal and embed themselves there, and of course break off. The grinding line was introduced in the States to assist the operator in keeping both lips of the drill identically the same. To arrive at this, however, is more than can be accomplished by hand-grinding, as not less than three points have to be carefully watched, viz.: 1st. That both lips are exactly the same length. 2nd. That both have the same clearance angles. 3rd. That both make the same angle with the centre line on the body of the drill. If these are not attended to, the drill lips may, for instance, be both ground so as to converge exactly to the grinding lines at the point or centre of the drill, and may still be of such different lengths and angles as to produce very bad results in drilling.

To give an idea of the extreme accuracy which must be imparted to a twist drill, we must bear in mind that even a good feed is only $\frac{1}{100}$in. to each revolution; and as two lips are employed to remove this thickness of metal, each lip has only half that quantity to cut, or $\frac{1}{200}$in. This $\frac{1}{200}$in. is as much as can be taken in practice by each lip in drills of ordinary sizes.

It will, therefore, be readily understood that if one lip of a drill stands before the other to the extent of $\frac{1}{100}$in. only, the prominent lip, or portion of a lip, will have to remove the whole thickness of the metal from the hole at each turn. The lip of a drill will not stand such treatment; and it is, therefore, obvious that if this were attempted, the prominent lip would either break or become rapidly blunted. To get over these difficulties, the driller would no doubt reduce his feed by one-

half, or to $\frac{1}{200}$in. per turn, which would mean about half the number of holes drilled in a given time. This nice accuracy, although absolutely required, cannot be produced by hand-grinding; neither can a common drill, having a rough black stem more or less eccentric, be ground accurately, even by aid of a grinding machine with mechanism for holding it. To grind any drill accurately, it must be concentric and perfectly true throughout with the shank, as that part has to be held by the drill-grinding machine. If the drilling is to be done in the most rapid manner—in other words, at the smallest cost—and if the best class of work is also desired, it seems certain that a twist drill, with all the accuracy which can possibly be imparted to it in its manufacture, and the greatest care employed in the re-sharpening, is the only instrument that can be employed.

Much ingenuity has been expended on machines for the grinding of the two lips with mechanical accuracy. The one which has been the most successful in the United States has three motions, ingeniously combined with each other. So many motions, however, entail complication, and this, added to a system of holding the drill which was not sufficiently reliable, failed to produce the extreme accuracy it is requisite to impart to the two angles. The grinding line, too, is found to be more or less a source of weakness. It is, therefore, advisable to dispense with it, if possible; and where a good twist drill grinding machine is used, the grinding line is seldom or never looked at, and in that case is useless. If it is still desirable to have grinding lines (as in some cases where hand-grinding has to be relied upon), they should be made as faint as possible, and not cut deeply into the thin central part of the drill, so as to weaken it.

A simple and efficient twist drill grinding machine has been designed within the last four years. The twist drill in this machine has only one motion imparted to it to produce the

two lips of each drill as perfect facsimiles of each other, and with the desired amount of clearance. Many of these machines are now at work. That the drills ground by them are accurate is proved by the holes drilled being so nearly the size of the twist drill itself that in many cases the drill will not afterwards drop vertically through the drilled hole by its own gravity—in other words, the hole is no larger than the drill which has drilled it. This is the most severe test that can be made of the accuracy of re-grinding, and of the uniformity of all parts of the twist drill.

The whole of the drilling in many establishments is now done entirely by twist drills. Since their introduction it is found that the self-acting feed can be increased about 90 per cent.; and in some engineering works the feeds in some machines have been increased by fully 200 per cent., and, consequently, three holes are now being drilled in the same time that one was originally drilled with the old style of drill and with old machines. It may be interesting to give a few results out of numerous tests and experiments made with the twist drills. Many thousands of holes $\frac{1}{2}$in. in diameter and $2\frac{3}{4}$in. deep have been drilled, by improved $\frac{1}{2}$in. twist drills, at so high a rate of feed that the spindle of the drilling machine could be seen visibly descending and driving the drill before it. The time occupied from the starting of each hole, in a hammered scrap-iron bar, till the drill pierced through it, varied from 1 minute 20 seconds to $1\frac{1}{2}$ minutes. The holes drilled were perfectly straight. The speed at which the drill was cutting was nearly 20ft. per minute at its periphery, and the feed was 100 revolutions per inch of depth drilled. The drill was lubricated with soap and water, and went clean through the $2\frac{3}{4}$in. without being withdrawn; and after it had drilled each hole it felt quite cool to the hand, its temperature being about 75°. It is found that 120 to 130 such holes can

be drilled before it is advisable to re-sharpen the twist drill. This ought to be done immediately the drill exhibits the slightest sign of distress. If carefully examined, after this number of holes has been drilled, the prominent cutting parts of the lips which have removed the metal will be found very slightly blunted or rounded, to the extent of about $\frac{1}{100}$ of an inch; and on this length being carefully ground by the machine off the end of the twist drill, the lips are brought up to perfectly sharp cutting edges again.

The same-sized holes, $\frac{1}{2}$in. diameter and $2\frac{3}{4}$in. deep, have been drilled through the same hammered scrap-iron at the extraordinary speed of $2\frac{3}{4}$in. deep in one minute and five seconds, the number of revolutions per inch being 75. An average number of 70 holes can be drilled in this case before the drill requires re-sharpening. The writer considers this test to be rather too severe, and prefers the former speed. The drills in each case were driven by a true-running drilling-machine spindle, having a round taper hole, which also was perfectly true; and the taper shank and body, or twisted part of the drills, also ran perfectly concentric when placed in the spindle, or in a reducer, or socket having a taper end to fit the spindle. When the drills run without any eccentricity, there is no pressure, and next to no friction, on the sides of the flutes, the whole of the pressure and work being taken on the ends of the drills. Consequently, they are not found to wear smaller in diameter at the lip end, and they retain their sizes, with careful usage, in a wonderful manner. The drills used were carefully sharpened in one of the twist drill grinders mentioned above. Upwards of 3,000 holes were drilled, $\frac{3}{8}$in. diameter, and $\frac{3}{8}$in. deep, through steel bars by one drill without re-grinding it. The cutting speed was in this instance too great for cutting steel, being about 18ft. to 20ft. per minute; and the result is extraordinary. Many thousands of holes

were drilled, $\frac{1}{8}$in. diameter, through cast iron $\frac{7}{16}$in. deep, with straight-shanked twist drill gripped by a chuck in the end of the spindle by a quick-speed drilling machine. The time occupied for each hole was from nine to ten seconds only. Again, $\frac{1}{4}$in. holes have been drilled through wrought copper, $1\frac{3}{8}$in. thick, at the speed of one hole in ten seconds. With special twist drills, made for piercing hard Bessemer steel rail, holes, $\frac{13}{16}$in. deep and $\frac{29}{32}$in. diameter, have been drilled at the rate of one hole in one minute and twenty seconds, in an ordinary drilling machine. Had the machine been stiffer and more powerful, better results could have been obtained. A similar twist drill, $\frac{29}{32}$in. in diameter, drilled a hard steel rail $\frac{13}{16}$in. deep in one minute, and another in one minute ten seconds. Another drill, $\frac{5}{8}$in. diameter, drilled $\frac{3}{4}$in. deep in 38 seconds, the cutting speed being 22ft. per minute. This speed of cutting rather distressed the drill; a speed of 16ft. per minute would be better. The steel rail was specially selected as being one of the hardest of the lot.

Small drills, such as are used by watchmakers, are generally made by filing the round steel wire slightly tapering, and then spreading the small end with a single blow from a tolerably heavy hammer. Using a light hammer, and effecting the spreading by a series of gentle taps, will effectually spoil the steel. There is no occasion to anneal the steel for hammering, providing it is moderately soft. For all drills up to one-eighth of an inch diameter, the steel should not be forged, as the bulk of the metal is too small to heat any predetermined temperature with any degree of certainty. Very small drills can be made from good sewing-needles, which are of convenient form to be readily converted into a drill. Firstly, the needle must be made sufficiently soft for working by heating till it assumes a deep blue colour. The extreme end may be made quite soft, and filed, slightly tapering to a trifle less than

the size of the hole to be drilled. The point is now spread out by a sharp blow of a hammer—not by a series of gentle taps, which would cause the metal to crack—and filed up to shape, the point being made more blunt than would be used for drilling ordinary metal. For drilling tempered steel, the cutting angles must also be much less than usual. The thickness of the drill across the flattened part should be about a third the diametrical measurement. Finish up the end on a strip of Arkansas stone, a file being too coarse for such small work. It is the great difficulty of getting such a very small piece of steel to an exact predetermined degree of temperature—hot enough to harden, but not so hot that it is burned—which makes the manufacture of these small tools uncertain; and this is abundantly proved by the fact that of half-a-dozen drills made from the same wire, thereby assuring uniformity of quality in the material, it often happens that some are exceedingly good and others of no use whatever, the difference being caused by the manipulation during hardening. This does not apply to drills or other steel things which are of sufficient size to show, by the colour of their surface, how hot they are; but it is the tiny pieces which by the contact with the flame are immediately rendered white hot that are difficult to manage. By heating the drill and plunging it into the body of a tallow candle, the hardening will be effected, but the steel will not be rendered so hard that it crumbles away under pressure in use. Thus, in one operation, the drill will be hardened and tempered. Instead of tallow, white wax, sealing wax, and such like materials, are adapted to the purpose. There is another method which finds favour with some: it is to envelop the thin point of the drill in a metal casing, and so get a bulk of metal which can be heated to a nicety, the drill inside being, of course, raised to the same temperature as the surrounding metal. The whole is then plunged into oil or water. Still,

there is the difficulty of tempering to overcome, though the danger of burning is avoided: burnt steel is of no use for tools. The best plan is to exercise the greatest possible care not to over-heat the drill, and harden and temper in one operation by plunging into tallow.

TABLE OF SPEEDS FOR TWIST DRILLS.

Diam. of Drills.	Revolutions per Minute			Diam. of Drills.	Revolutions per Minute.		
Inch.	For Steel.	For Iron.	For Brass.	Inch.	For Steel.	For Iron.	For Brass.
$\frac{1}{16}$	940	1280	1560	$1\frac{1}{16}$	54	75	95
$\frac{1}{8}$	460	660	785	$1\frac{1}{8}$	52	70	90
$\frac{3}{16}$	310	420	540	$1\frac{3}{16}$	49	66	85
$\frac{1}{4}$	230	320	400	$1\frac{1}{4}$	46	62	80
$\frac{5}{16}$	190	260	320	$1\frac{5}{16}$	44	60	75
$\frac{3}{8}$	150	220	260	$1\frac{3}{8}$	42	58	72
$\frac{7}{16}$	130	185	230	$1\frac{7}{16}$	40	56	69
$\frac{1}{2}$	115	160	200	$1\frac{1}{2}$	39	54	66
$\frac{9}{16}$	100	140	180	$1\frac{9}{16}$	37	51	63
$\frac{5}{8}$	95	130	160	$1\frac{5}{8}$	36	49	60
$\frac{11}{16}$	85	125	145	$1\frac{11}{16}$	34	47	58
$\frac{3}{4}$	75	105	130	$1\frac{3}{4}$	38	45	56
$\frac{13}{16}$	70	100	120	$1\frac{13}{16}$	32	43	54
$\frac{7}{8}$	65	90	115	$1\frac{7}{8}$	31	41	52
$\frac{15}{16}$	62	83	110	$1\frac{15}{16}$	30	40	51
1	58	80	100	2	29	39	49

Experience in the use of both twist and flat drills in boring holes of various sizes in different kinds of metals has proved the most advantageous velocities that their surfaces can be run—considering the durability of the drills, the amount of work they can do in a given time, and the cost of labour expended in running them while boring holes in metals—to be as follows:—On steel, 15 ft. per minute, when in the condition usually worked; wrought, malleable and cast iron, 20 ft. per minute, when in their usual working conditions; brass and kindred metals, 25 ft. per minute. The preceding table shows the diameters of twist drills, as usually made

and sold in the markets, from $\frac{1}{16}$ of an inch upwards; also the number of turns per minute each size has to be run to have its periphery run on the scale of velocities per minute mentioned above, when boring holes in steel, iron and brass.

The Morse Twist Drill and Machine Company publish the foregoing table, showing the number of revolutions per minute for drills from $\frac{1}{16}$ in. to 2 in. diameter, applied to steel, iron and brass respectively, in the usual way. To drill 1 in. deep in soft cast iron will usually require: For $\frac{1}{4}$ in. drill, 125 revolutions; for $\frac{1}{2}$ in. drill, 120 revolutions; for $\frac{3}{4}$ in. drill, 100 revolutions; for 1 in. drill, 95 revolutions.

CHAPTER IX.

ABRASIVE AND FINISHING PROCESSES.

ABRASIVE processes range from coarse grinding for the purpose of shaping the metal to fine polishing, which produces finish on the surface. Grinding, as practised in the production of edged tools, forms the subject of a previous chapter, which may be read with the present one.

The whole process of polishing consists merely of substituting finer scratches for those which are coarse, and so continuing till the desired finish is attained; but even then the surface, if examined with a magnifying glass, will appear full of scratches. It is evident that great care must be taken to have the polishing materials uniformly fine, for even one or two grains of a coarser grit will produce ugly scratches instead of a perfectly uniform surface.

Glaze wheels covered with leather and dressed with Tripoli powder, rotten-stone, oxide of tin or putty powder, crocus and rouge, or some other polishing material, are used to produce highly-polished surfaces.

Emery-wheels are now manufactured in large quantities and retailed by shopkeepers throughout the kingdom. Grains of emery are consolidated into wheels of all sizes and forms, and a simple simile of their use is that the emery-wheel is to the file what the circular-saw is to the hand-saw. It is a rotary file whose cutting-points never grow dull. Emery-wheels used as files will, in one minute, do work equivalent to that produced by file-strokes a mile long. In other words the emery-wheel will do in one minute work that would employ a filer over one

hour. Emery-cloth is also largely used for grinding purposes, and, stretched over a flat surface, it will finish a surface better than a file.

The Grecian and Turkish emery is shipped in blocks of various size, from 150lbs. in weight down to pieces the size of an egg. In its preparation, the blocks are broken up under hammers, until of a proper size to be placed in rock-crushers, which reduce the emery to fragments as small as walnuts. These are placed under stampers, rollers, and crushing machines until the whole is reduced to the required fineness. It is then conveyed to the sifting machines to separate the various grades of grain. The meshes of wire (or lawn for the finer) used for obtaining the various grades vary from sixty to many thousand holes to the square inch. The grades have sizes and numbers corresponding respectively to the number of meshes in a lineal inch of bolting cloth. The very fine emery is suspended in water, and then assorted by precipitation. The finest floats in the atmosphere of the stamping room, and is deposited on the beams and shelves, from which it is occasionally collected.

Fragments of oilstone, when pulverised, sifted and washed, are much in request by mechanicians. This abrasive is generally preferred for grinding together those fittings of mathematical instruments and machinery which are made wholly or in part of brass or gun-metal; for oilstone, being softer and more pulverulent than emery, is less liable to become embedded in the metal than the latter, which is then apt continually to grind and ultimately damage the accuracy of the fittings of brass works. In modern practice it is usual, however, as far as possible, to discard the grinding together of surfaces, with the view of producing accuracy of form or precision of contact. Oilstone powder is preferred to pumice stone powder for polishing superior brass work,

and it is also used by the watchmakers on rubbers of pewter in polishing steel.

Pumice stone is a volcanic product, and is obtained principally from one of the Lipari islands, which is composed entirely of this substance. It is extensively employed in various branches of the arts, and particularly in the state of powder, for polishing the various articles of cut glass; it is also extensively used in dressing leather, and in grinding and polishing the surface of metallic plates, etc. Pumice stone is ground or crushed under a runner, and sifted, and in this state it is used for brass and other metal works; and also for japanned, varnished, and painted goods, for which latter purposes it is generally applied on woollen cloths with water.

Nothing is more necessary to the successful use of polishing powder than equality in the grain. Fine dust clogs the action of coarse grinding powders, and prevents them from rapidly cutting the object to be ground; coarse particles mixed with fine polishing powder scratch the article and render the repetition of grinding and polishing necessary. To secure fineness and uniformity, no process equals that of elutriation, which is thus performed:—Suppose it were desired to separate the ordinary flour emery into three different degrees of fineness. Take three vessels, such as pails or jars, and mix the emery with a large quantity of water—say, one quart of water to $1\frac{1}{2}$oz. of emery. Stir the mixture until the emery is thoroughly diffused through the liquid, and allow it to stand five minutes. By this time all the heavier particles will have settled, and on pouring the fluid into a second jar only the finer portion will be carried over. So continue to wash the first residuum until nearly all the particles have subsided at the end of five minutes, and the water is left comparatively clear. You will now have the coarse portion (No. 1) by itself. So from the sediment collection from washings of No. 1 you

may collect a portion (No. 2) having a second degree of coarseness. The last and finest will be obtained by letting the final washings stand ten or fifteen minutes, pouring off the liquid, and allowing it to settle.

Slips of wood called buff sticks, covered with buff leather, are used in numerous polishing processes, some abrasive material being spread on them suited to the work in hand.

The principal polishing powders are chalk or whiting, crocus or rouge, emery, oilstone powder, and putty, which latter consists chiefly of oxide of tin. Other powders, such as Tripoli, bathbrick, sand, etc., are rarely used for the finer kinds of work. Commercial whiting contains particles of silica of varying size, which cut freely, but are apt to scratch. Pure whiting, which is easily got by careful elutriation, has very poor cutting qualities, and is therefore used chiefly as plate powder for cleaning gold, silver, glass, etc., and for absorbing grease from metals which have been polished by other means.

Chalk is usually prepared specially for polishing. The chalk is thoroughly pulverised and mixed with clear rain-water in the proportion of two pounds to the gallon. Stir well and let it stand about two minutes. In this time the gritty matter will have settled to the bottom. Pour the water into another vessel, slowly, so as not to stir up the settlings. Let stand until entirely settled, and then pour off as before. The settlings in the second vessel will be your prepared chalk, ready for use as soon as dried. Spanish whiting treated in the same way makes a very good cleaning or polishing powder. Some add a little jeweller's rouge, which gives the powder a colour, and adds to its value in the eyes of the uninitiated. In cases where a sharper polishing powder is required, it may be prepared in the same way from rotten-stone. Chalk is frequently manufactured specially by adding a solution of carbonate of soda to a solution of chloride of calcium (both

cheap salts) so long as a precipitate is thrown down. The solutions should be carefully filtered through paper before being mixed, and dust should be rigorously excluded. The white powder which falls down is carbonate of lime, or chalk, and when carefully washed and dried it forms a most excellent polishing powder for the softer metals. The particles are almost impalpable, but seem to be crystalline, for they polish quickly and smoothly, though they seem to wear away the material so little that its form or sharpness is not injured to any perceptible degree.

Crocus or rouge is manufactured in the following manner:—crystals of sulphate of iron (green vitriol or copperas) are taken immediately from the crystallising vessels in the copperas works so as to have them as clean as possible, and instantly put into crucibles or cast-iron pots, and exposed to heat, without suffering the smallest particle of dust to get in, which would scratch the article to be polished. Those portions which are least calcined, and are of a scarlet colour, are fit to make rouge for polishing gold or silver, while those which are calcined or have become red-purple or bluish-purple, form crocus fit for polishing brass or steel. Of these, the bluish-purple coloured parts are the hardest, and are found nearest to the bottom of the vessels, and consequently have been exposed to the greatest degree of heat.

Putty powder is the pulverised oxide of tin or generally of tin and lead mixed in various proportions. As a criterion of quality, it may be said that the whitest putty powder is the purest, provided it be heavy. Some of the common kinds are brown and yellow, while others, from the intentional admixture of a little ivory black, are known as grey putty. The pure white putty powder—which is used by the marble workers, opticians, and some others—is the smoothest and most cutting. It should consist of the oxide of tin alone; but to lessen the

difficulty of manufacture, a very little lead (the linings of tea chests), or else an alloy called shruff (prepared in ingots by the pewterers) is added to assist the oxidation. The putty powder of commerce, of good fair quality, is made of about equal parts of tin and lead, or tin and shruff; the common dark-coloured kinds are prepared of lead only, but these are much harsher to the touch, altogether inferior. Perhaps the most extensive use of putty powder is in glass and marble works, but the best kind serves admirably as plate powder, and for the general purposes of polishing. A little crocus is usually added to the putty powder by way of colouring matter, and it is then easier to learn the quantity of powder that remains on the polishing tool; this is the polishing powder employed in making achromatic object-glasses for astronomical telescopes.

The methods of finishing brass have been already mentioned. To obtain the finest degree of lustre on cutlery, the best cast-bar steel having a fine grain should be selected. After this has been forged, filed or otherwise shaped, to the required form—forging always improves steel if care is taken not to burn it—it passes through the following processes in the order indicated: Grinding, glazing, fine glazing, lapping, buffing, and, in some cases, burnishing. If possible, it should be hardened and tempered at least to a dark brown temper, as hardened steel takes better polish than soft steel. The black steel is ground first on a grindstone, running at a great velocity from the operator, as do all the wheels in the subsequent processes. The size of the stone depends on the class of work: for large surfaces, or quick, cheap grinding, the stone being often 10 ft. diameter and 1 ft. broad on the face; whilst for knives, razors, and scissors requiring to be hollow, it rarely exceeds 1 ft. and often only 6 in. diameter. Having uniformly ground off the scale and all protuberances, it is transferred to the glazing wheel, consisting of a wooden wheel, varying in size like

the grindstone, according to the character of the work, but rarely exceeding 2 ft. in diameter, generally only 12 or 15 in., and for small work 6 or 8 in. Round the periphery of this wheel is glued and fixed, with wooden pegs, a strip of thick leather, which is put on wet and allowed to dry; on this a layer of glue is put, and it is then rolled in No. 1 emery. The work is cautiously applied to this glazer, as it is called, which is revolved with great rapidity, care being taken not to allow the work to become so hot as to lose its temper. From this it is removed to the fine glazer, which is a coarse glazer which has worn smooth. By this time the work will have a very good appearance, and, for many purposes, it is fit for the market; but it is yet full of scratches.

The next wheel is called the lap wheel, which consists of a wooden wheel, round the outer rim of which is cast a ring of lead about ¼ in. thick. This is turned up perfectly true, and then rolled with pressure in flour emery. This lap converts the large scratches into very fine ones, and as the lead is a good conductor of heat, less care is required to keep the article cool. At this stage, in most cases, comes the final buffing; but, for the very best work, it is first polished on a leather-edged wheel covered with a paste of flour, emery and tallow. The grease must most carefully be cleaned off to ensure success in the final process. The wheel in this process is covered round the rim with thick buckskin, and turned up true with a sharp turning tool. For small work this is not necessary, provided the wooden part is turned true in its place, and thin leather is used. In putting on the leather, the two ends must be pared to a chamfer, so as not to cause a lump, and the direction of rotation is such as not to cause the work to open the joining. This wheel is charged with dry rouge powder. If the preceding operations have been properly performed, the work will readily assume an exquisite

polish. If the work requires to be accurately flat on any part the wheels are replaced by discs, the surfaces of which take the place of the rims in the above wheels; an experienced man, however, will do flat work of considerable size on the wheels without deteriorating much the truth of the surface. The process seems to be a long one, as knives and scissors are got up so cheap; but it is surprising with what rapidity the successive operations are gone through; and it must be remembered that some articles are often ground and glazed, a dozen at a time, by one man.

A process of finishing brass, called bright grey, is effected by means of rotten-stone mixed with oil, and applied with a boxwood slip. The surface of the work is first prepared by greying with water-of-Ayr stone.

The following is the process used by the mason to polish marble. With a piece of very fine grit sandstone rub the slab backward and forward, using very fine sand and water, till the marble appears equally rough and not scratched; next use a finer stone and finer sand, till its surface appears equally gone over; then with fine emery powder and a piece of felt or old hat wrapped round a weight, rub till all the marks left by the former process are worked out, and it appears with a comparative gloss on its surface. Afterwards, finish the polish with putty powder and fine, clean rags. As soon as the surface appears to have a good gloss, do not put more powder on the rags, but rub well, and in a short time the marble will appear as fresh as when new.

Japanning on metal is simply the process of laying a coat of varnish and afterwards drying by artificial heat. This second operation, the baking, is the essential part in japanning. The art was originated in Japan, whence we have derived the name. Many examples of japanning on *papier maché* may be seen at fancy repositories where various ornamental nicknacks

imported from Japan are on sale. In making this ware, the Japanese employ a lacquer which exudes from an indigenous tree. Successive coats are laid on, each one being thoroughly dried in the sun before the application of another. Thus a thick hard coating is made, which may be smoothed and polished by abrasive materials, though the natural lustre suffices for general requirements. Gilding and other ornamentation is then made to adhere by means of boiled oil. The whole is finally finished by a coat of clear varnish. The above is a rough sketch of the art as practised by the originators, but we have to deal with modern japanning, and confine our observations to its application to metal.

The japanner's oven is a receptacle in which the work is placed when being heated. Usually the heat is applied by means of external flues, in which hot air or steam is circulated. By this system the temperature may be regulated to great nicety, the supply of heat being controlled by dampers or stopcocks. A sheet-iron box, encased by another of the same shape, but somewhat larger in size, so that an interspace of an inch or two exists between them, is the most simple form of oven. Heat is applied to the interspace, and thus an even temperature is maintained. A flue must be provided, to carry off the vapours which arise from the japan.

A doorway, by which to introduce the articles, provided with a tolerably well-fitting door, is, of course, essential. Hooks or wire shelves are provided, by which the work is supported, so that the heat may take effect equally all round. Moisture, dust, and all other extraneous matter must be carefully excluded, so that the japanning may be kept perfectly clean and free from foreign substances. Thermometers are hung in the oven to indicate the precise degree of heat, which must be regulated to suit the requirements of particular work.

Metals require no special preparation before laying on the

japan. After being wrought to the desired shape, and smoothed as much as may be considered advisable, the article has only to be made thoroughly clean to prepare it for japanning. The surface must be quite dry, or the japan will not adhere properly. Wood requires to be primed and otherwise prepared for japanning.

Japan—that is, the paint-like material to be laid on the metal—is made of shellac varnish, with which should be incorporated the pigment necessary to produce a desired colour. Shellac varnish is made by dissolving shellac in alcohol. A better varnish for japanning is made by adding resin and shellac, 2 oz. of each, to a pint of methylated spirit. Any pigment may be added to such varnish to form japan of the colour required. A few formulæ may be useful. *Black:* Mix lamp-black or ivory-black—this latter preferably—with the above varnish. *Another Black:* Melt 1 lb. of asphaltum, and mix with the same quantity of balsam of capivi, thin the mixture to a workable consistency with hot oil of turpentine. *Another Black:* Mix lamp-black with oil of turpentine, and grind smooth on a muller; thin the mixture with copal varnish. *White:* Flake white, or white lead, ground up with a sixth of its weight of starch; this must be thoroughly dried and mixed with mastic varnish. *Yellow:* King's yellow is used as the pigment, but the effect is considerably improved by dissolving turmeric in the alcohol before adding the shellac to form the varnish.

Tortoiseshell japan is pretty, and comparatively easy to manipulate. The work is first coated with a japan made by boiling two pints of linseed oil, to which $\frac{1}{4}$ lb. of umber has been added, till it becomes thickened; the mixture is then strained and further boiled till it becomes of a pitchy consistency. This is mixed with turpentine to a workable consistency, and then applied. On a thoroughly dry coating

of this japan lay a quantity of vermilion spots to represent the clear portions of the shell. The vermilion japan is made by adding vermilion to shellac varnish; it should be laid on thinly and dried. The whole surface is then finally coated with a thin layer of the above-described brown japan, still further diluted with turpentine. A long course of stoving will be necessary to thoroughly harden the japanning.

The operation of japanning consists of driving off the solvents of the japan at a high temperature. When the article, covered with a coating of japan, is placed in the oven and submitted to a temperature of about 200° to 300° Fahrenheit, or even more, the solvents quickly evaporate. The residue, a gummy substance, with which is incorporated the colouring matter, is kept liquid by the heat, and in the semi-liquid state forms a smooth coating, filling any small inequalities of the surface. The baking process secures a very firm adhesion of the japan to the metal, far superior to that of ordinary varnish or paint. The japan is also made hard, and consequently better able to resist wear. When one coat is dried, another is applied and submitted to the action of heat. These operations are repeated, as may be deemed necessary, from one to six times. Each succeeding coat of japan will present a more uniform and glassy surface. The natural flow of the japan generally suffices to produce a good smooth surface, but in some cases a process of polishing is resorted to before the application of the final coat.

The temperature for light-coloured japans must not be sufficiently high to scorch, or the surface will, of course, be discoloured. Dark japans are usually dried at a very high temperature, if the article is not likely to be injured by heat. The final coating of japan is generally a layer of clear varnish which will add to the lustre of the surface.

INDEX.

PAGE

ABRADENTS, Crushing .. 121
Abrasive Processes 120
Accuracy of Twist Drills .. 112
Alloys, Chantrey's 46
——— Collins's, Red 46
——— Collins's, White 46
——— Collins's, Yellow 46
——— Definition of 10
——— Ductility of 11
——— For Soldering 58
——— Fusible.. 13
——— Hardness of 11
——— Melting Points of 11
Aluminium 2
——— Solder 66
Amalgam, Definition of 10
Ancient Files 70
Annatto for Lacquer 50
Annealing 15
——— Steel 32
Antimony.. .. .. .. 2, 12
——— For Bronzing.. 53
Antique Bronzing 53
Arkansas Oilstone 96
Arsenic 2
Artificial Grindstone 92
Art of Tool Grinding 102
Atomic Weights of Metals 2
Axles, Carriage 5

BANDSAW File 74
Bar Iron 5
Bastard Files 70
Bathbrick.. 123
Bath Metal 46
Baths for Tempering Metals.. .. 35
Bilston Grindstones 92
Bismuth 2, 12
Blanks for Files.. 75
Blowpipe for Soldering 62
Boiling Steel 7
Borax for Soldering 62
Brass 11, 44
——— Bright Grey for 127
——— Common 46
——— Emerson's 46
——— German 46
——— Rusting 53
——— Soldering 64
——— Speed for Drilling 118
——— Wire 46
Brassfinisher 46

PAGE

Brassfinishing, Emery for 47
Brassfinishing, High-class 47
——— Oilstone, Powder for .. 47
Brazing 56
Brick, Bath- 123
Bright Grey for Brass 127
Brittleness of Iron 5
Bronze 11
Bronzing, Green 54
——— Hyposulphite of Soda for .. 54
——— Japanese 54
——— Nitrate of Iron for 54
——— Nitrate of Tin for 54
——— Olive Green 54
——— Perchloride of Iron for .. 53
——— Platinum 54
Brown Bronzing 53
Brush for Lacquering 52
Buffing Cutlery 125
Buff Sticks 123
Burning together 56
Burnishing 87
Burnt Steel 29
Buttons, Soldering 65
Butt Weld 20

CABINET Files 74
Cabinet Rasps 70, 74
Cadmium 2
Cape Aloes, for Lacquer 50
Carbon and Iron 4
Carriage Axles 5
Case Hardening.. 22
Castings, Chipping 81
Cast Iron, Filing 81
Cast Steel.. 7
——— Crucible 7
Chalk 123
Chantrey's Alloy 46
Characteristics of Metals 2
Charcoal Fire 29
Charnwood Forest Stone 97
Chipping Castings before Filing .. 81
Chisel Temper 8
——— for File Cutting 75
——— Sharpening 99
Chloride of Antimony Bronzing .. 53
——— Arsenic Bronzing 54
——— Gold Bronzing 54
Chocolate Bronzing 53
Choosing a Good File 80
Chromium 2, 10

PAGE
Cleaning Files 86
Cleanliness necessary for Soldering 63, 68
Clogged Files 86
Coach Bolts, Forging 17
Coarseness of Files 71
Coarse Solder 66
Cobalt 2
Cock Metal 14
Coke Fire.. 29
Cold Lacquering 50
Cold Short Iron 4
——— Solder 68
Collins's Red Alloy 46
——— White Alloy 46
——— Yellow Alloy 46
Common Brass 46
Conductivity of Electricity in Metals 2
——— Heat in Metals 2
Contraction in Hardening 35
Cooling Steel 33
Copper 2, 14
——— Forged.. 10
Cotter File 71
Crocus 123
——— Making.. 124
Crossing File 73
Crucible Cast Steel 7
Crushing Abradents 121
Curling 48
Cut of Files 70
Cutlery, Buffing.. 125
——— Grinding 125
——— Lapping 125
——— Polishing 125
Cutting Edges 88
——— Files, Chisels for 75

DEADSMOOTH Files 70
Definitions of Iron and Steel 6
Diamagnetic Metals 2
Die Temper 9
Dipping 52
Double Cut Files 70, 74
Dragon's Blood for Lacquer.. .. 50
Drawfiling 87
Drawing Instruments, Soldering .. 65
Drill File 72
Drilling 104
——— Speeds for 118
Drills 104
——— Accuracy of Twist 112
——— Hardening and Tempering 117
——— Machines for Grinding .. 113
Ductility of Alloys 11
——— of the Metals 2

EASY Running Solder 64
Edges, Cutting.. 88
Emerson's Brass 46
Emery 123
——— Grading 121
——— Paper 47
——— Separating 122
Equaling File 72
Even Heating for Steel 30
Expansion of Metals 2

PAGE
FAGGOTING Iron .. 5, 21
Files 70
——— Ancient 70
——— Bastard 70
——— Blanks for 75
——— Cabinet 70, 74
——— Cards for 86
——— Choosing 80
——— Cleaning 86
——— Clogged 85
——— Coarseness of 71
——— Cotter 71
——— Crossing 73
——— Cut of 70
——— Cutting 75
——— Dead Smooth.. 70
——— Double Cut 70, 74
——— Drill 72
——— Equaling 72
——— Flat 72
——— Float 73
——— Half-round 73
——— Hammers for Cutting .. 75
——— Hand 71
——— Handles for 85
——— Hardening 79
——— Joint 72
——— Kind of.. 70
——— Length of 70
——— Manufacturing 75
——— Over Cut 70
——— Parallel Round 72
——— Parallel Square 71
——— Parallel Triangular 73
——— Peculiarities of 70
——— Pillar 71
——— Pins in 87
——— Pivot 71
——— Rough 70
——— Round 72
——— Saw 73
——— Second Cut 70
——— Single Cut 70
——— Smooth 80
——— Softening Tangs 80
——— Three Square 73
——— Triangular 73
——— Up Cut.. 70
——— Warding 72
Filing, Art of 81
——— Chipping Castings for .. 81
——— Large Work 83
——— Mouldings 86
——— Small Work 83
Filing-out Grooves 86
Fine Glazing Cutlery 126
——— Gold 10
——— Silver 10
Finest Grained Steel 9
Finishing Processes 120
Fire Charcoal 29
——— Coke 29
Flat Files 72
——— Filing 81
——— Drills 105, 109
Float File.. 73
Fluxes for Soldering 60
Forging 16

PAGE

Forging Bolts 17
——— Copper.. 10
——— Gold 10
——— Steel 28
Fracture of Iron 4
Fusible Alloys 13

GAMBOGE for Lacquer.. .. 50
Gas Pipe Soldering 67
German Brass 46
——— Hones 98
——— Silver Soldering 66
Glazing Cutlery.. 126
——— Wheels.. 94
Gold 2
——— Bronzing 54
——— Fine 10
——— Forged.. 10
——— Lacquer 49
——— Manheim 46
——— Mosaic.. 46
——— Solder 62, 66
Goniometer 100
Good Welding 19
Grading Emery 121
Granulating Solders 65, 67
Green Bronzing.. 54
Grinding Cutlery 126
——— Tools 102
Grindstones, Artificial.. 92
——— Natural 95
——— Usefulness of.. 89
Grooves, Filing 86

HALF-ROUND Files 73
Hammers for File Cutting.. 75
Hand Files 71
Handles for Files 85
Hardening, and Tempering in One Operation 117
Hardening, Contraction in 35
——— Files 79
——— Oil for 36
——— Steel 26
Hardness of Alloys 11
——— of Iron 5
Hard Silver Solder 66
——— Soldering 56
——— Spelter Solder 66
Heat, Even, for Steel 30
——— Soldering without 68
Heating Steel to Harden 29
Height of Vice for Filing 83
High-class Brassfinishing 47
——— Quality Steel.. 32
Hones 95
——— German 98
——— Levelling 98
——— Oil for 98
——— Tam o' Shanter 97
——— Water for 98
Horse Rasps 70
Hot Lacquering.. 51
—— Short Iron 4
Hydrochloric Acid for Soldering .. 60
Hyposulphite of Soda for Bronzing 54

PAGE

INGOT Iron 7
——— Steel 7
Iridium 2
Iron 3
——— Bar 5
——— Brittleness of.. 5
——— Carbon and 4
——— Cold Short 4
——— Definition of 6
——— Faggoting 5
——— Fracture of 4
——— Hardness of 5
——— Hot Short 4
——— Ingot 7
——— Phosphorus and 4
——— Soldering 64, 67
——— Speed for Drilling 118

JAPANESE Bronzing 54
——— Lacquer 128
Japanner's Oven.. 128
Japanning Metal 128
——— Operation of 130
Japans, Formulæ for 129
Jewellery, Soldering 62, 65
Joint File 72
Jump Weld 20

KILLING Steel 7
Kind of Files 70

LACQUERING 50
——— Brush for 51
——— Cold 50
——— Hot 51
Lacquers, Annatto for 50
——— Cape Aloes for 50
——— Dragon's Blood for 50
——— Gamboge for 50
——— Gold 49
——— Japanese 128
——— Pale Gold 49
——— Proportions for 54
——— Red 49
——— Red Sanders for 50
——— Saffron for 50
——— Sandarac for 50
——— Spirit 50
——— Turmeric for 50
——— Yellow 50
Lamp for Soldering 63
Lapping Cutlery 126
Laps 94
Large Work, Filing 83
Lathe Mandrels.. 5
Lead 2, 10, 12
Length of Files 70
Levelling Hones 99
Linear Expansion of Metals.. .. 2
Long Tubes, Soldering 66
Low Quality Steel 27

PAGE

MACHINE or Grinding Twist Drills 113
——— Planing 81
Magnesium 2
Magnetic Metals 2
Making Crocus 124
——— Chalk 123
Malleability of the Metals 2
Malleable Iron 3, 6
Mandrels, Lathe 5
Manganese 2
——— in Steel 8
Manheim Gold 46
Manufacturing Files 75
Marble, Polishing 127
Melting Points of Alloys 11
——— Points of Metals 2
——— Solders 67
Metals 1
——— Atomic Weights of 2
——— Baths for Tempering .. 35
——— Characteristics of 2
——— Diamagnetic 2
——— Ductility of 2
——— Electrical Conductivity of.. 2
——— Heat, Conductivity of .. 2
——— Japanning 128
——— Linear Expansion of .. 2
——— Magnetic 2
——— Melting Points of 2
——— Muntz's 46
——— Mushet's 46
Mercury 2
Methods of Soldering 61
Mild Centred Steel 9
Mixing Solders 67
Mock Platinum 46
Mosaic Gold 46
Mouldings, Filing 86
Muntz's Metal 46
Muriatic Acid for Soldering 60
Mushet's Metal 46
Mushroom Headed Bolt Forging .. 17

NATURAL Grindstones 95
——— Nickel 2
——— Nitrate of Iron Bronzing .. 54
——— Tin Bronzing 54
Norway Ragstones 97
Nova-Scotia Oilstones.. 97

OBJECT of Tool Grinding .. 102
Oil for Hones 98
——— Hardening Steel .. 36
Oilstones 95
——— How to Use 99
——— Nova-Scotia 97
——— Ouachita 97
——— Powder for Brass-finishing 47
——— Turkey.. 96
——— Washita 97
Olive Green Bronzing.. 54
Ormolu 46
Ouachita Oilstone 97
Oven, Japanner's 128
Overcut Files 70

PAGE

Overheating 19
Overworking 19
Oxidation of Solders 67

PALE Gold Lacquer 49
Palladium 2
Parallel Round File 72
——— Square File 71
——— Triangular File 73
Peculiarities of Files 70
Peculiar Kinds of Steel 9
Perchloride of Iron, Bronzing .. 53
Pewterer's Solder 66
——— Soft Solder 66
Phosphoric Acid for Soldering .. 60
Phosphorus and Iron 4
——— Steel 8
Pickle for Soldering 64
Pickling 54
——— Casting.. 81
Pig Iron 4
Pillar Files 71
Pinchbec 46
Pins in Files 87
Pivot File.. 71
Plain Iron Setting 101
Planing Machine 81
Platinum 2
——— Bronzing 54
——— Mock 46
——— Soldering 66
Plumber's Solder 66
Polishing 87
——— Cutlery 125
——— Marble 127
——— Processes 120
Position for Filing 82
Pot Metal.. 14
Processes, Finishing 120
Properties of Metals 2
Proportions for Lacquers 54
Puddled Steel 7
Pulverised Oilstone 96
Pumice Stone 122
Pure Iron 3
Putty 123
Putty Powder Making.. 125

QUENCHING Steel 33

RAGSTONES 97
——— Norway.. 97
——— Russian.. 97
——— Scotch 97
Rasps, Cabinet 70, 74
——— Cutting.. 78
——— Horse 70
Razor Temper 8
Red Alloy.. 46
——— Brass 46
——— Lacquer 50
——— Oxide of Iron Bronzing .. 54
——— Sawdust for Lacquer .. 52
——— Short Iron 4

	PAGE
Re-lacquering	52
Resin for Soldering	60
Revere's Metal	46
Rhodium	2
Rolled Brass	46
—— Solders	65
Rottenstone for Brass-finishing	47
Rouge	123
Rough Files	70
Round Files	72
Russian Ragstones	97
Rusting of Brass	53
SAFFRON for Lacquer	50
Salammoniac for Soldering	60
Sand	123
Sandarac for Lacquer	50
Sawfile	73
—— Taper	74
—— Temper	8
Scale on Iron	3
Scarf Weld	20
Scotch Ragstone	97
Second Cut File	70
Seedlac	49
Semilor	46
Separating Emery	122
Setting Plane Iron	101
Sett Temper	9
Shape of Flat Drills	110
Sharpening Chisels	99
Shellac	49
Shoe Rasps	70
Silicon in Steel	8
Silver	2
—— Fine	10
—— Forged	10
—— Soldering	61, 64
Single Cut File	70
Slate Stone, Welsh	97
Slim Taper Saw File	74
Small Drills	116
Small Surface, Filing	85
Small Tools, Grinding	102
Small Work, Filing	74
Smooth Files	70
Snakestone	97
Soaking Heat	19
Sodium	2
—— Solder	68
Softening Tangs of Files	80
—— Steel	32
Soft Silver Solder	66
Solder	56
—— Aluminium	66
—— Coarse	66
—— Cold	68
—— Easy Running	64
—— Filigree	64
—— Gold	62
—— Granulating	67
—— Hard Silver	66
—— Hard Spelter	66
—— Melting	67
—— Mixing	67
—— Oxidation of	67
Solder, Pewterer's	66
—— Plumber's	66
—— Rolled	65
—— Salammoniac for	60
—— Silver	66
—— Silver, Soft	66
—— Silver, Various	63
—— Sodium	68
—— Soft Pewterer's	66
—— Steel	66
—— Sweating	57
—— Tinman's	66
—— Wire	59
Soldering	56
—— Alloys for	58
—— Bit	67
—— Borax for	62
—— Buttons	65
—— Cleanliness necessary	63, 68
—— Cold	68
—— Drawing Instruments	65
—— Fluxes for	60
—— Gas Pipe	67
—— German Silver	66
—— Hard	66
—— Hydrochloric Acid for	60
—— Iron	64
—— Jewellery	62, 65
—— Lamp for	63
—— Methods of	61
—— Muriatic Acid for	60
—— Phosphoric Acid for	60
—— Pickle for	64
—— Resin	60
—— Silver	61
—— Tubes	60, 67
—— Without Heat	68
Special Sizes and Grades of Steel	42
Specific Heat of Metals	2
—— Gravities of Metals	2
Speculum Metal	13, 48
Speed and Feed for Drilling	108, 114, 118
Spindle Temper	8
Spirit Lacquer	50
Spirits of Salts for Soldering	60
Spontaneous Combustion of Iron	3
Square Files	71
Standing for Filing	83
Statuary Brass	46
Steel	3, 6, 26
—— Definitions of	6
—— Even Heat for	30
—— Finest Grained	9
—— Forging	28
—— Grey Bronzing	54
—— Hardening	26
—— Ingot	7
—— Killing	7
—— Low Quality	27
—— Manganese in	8
—— Mild Centred	9
—— Phosphorus in	8
—— Soldering	64
—— Solders	66
—— Table of Speeds for Drilling	118
Sticks, Buff	123
Straightening Files in Hardening	79
Strong Cold Solder	68

PAGE

Sulphate of Copper Bronzing .. 54
Sulphur in Iron.. 4
——— in Steel 8
Surface Hardening 53
Symbolic Equivalents of the Metals 2

TABLE of Speeds for Twist Drills 118
Tam o' Shanter Hone .. 97
Taper Saw File 73
Tear Solder 59
Temperature for Colours on Steel .. 39
Temper, Chisel 8
——— Die 9
Tempering in Metal Baths 35
Tenacity of Alloys 11
——— of Metals 2
Tensile Strength of Metals 2
"Three Square" File 73
Tin 2, 10
Tinman's Solder 66
Tombac 46
——— Red 46
Tool Grinding 88
——— Object of 102
Tool Temper 8
Tortoiseshell Japan 129
Tough Brass 46
Triangular Files 73
Tripoli 123
Trueing Grindstones 92
Tubes, Soldering 65
Tungsten 2, 9
Turkey Oilstone 96
Turmeric or Lacquer.. 50
Tutenag 46
Twist Drills 110

UNIFORM Heat for Soldering 65
Universal Names 6
Upcut Files 70
Up Setting 17
Usefulness of Grindstones 89
Using Oilstones.. 99

VARNISH 49
Verdigris, Coating of.. .. 54
Versailles Brass 46
Vice for Filing 82
Violet Bronzing.. 53

WARDING File 72
Washita Oilstones.. .. 97
Water Cracks 37
Water for Hones 98
Water-of-Ayr Stone . .. 48, 97
Weld, Butt 20
——— Iron 7
——— Jump 20
——— Scarf 20
——— Steel 7
Welding 18
——— Iron 5
Welsh Slate Stone 97
Wheels, Glazing 94
White Alloy 46
——— Brass 46
Whiting 123
Wire, Brass 46
Wolfram 9
Wood Rasps 70, 74
Wrought Iron 7

YELLOW Alloy 46
——— Brass 45
——— Lacquer 50

ZINC 2, 10

OGDEN, SMALE AND CO. LIMITED, PRINTERS, GREAT SAFFRON HILL, E.C.

7, STATIONERS' HALL COURT, LONDON, E.C.
February, 1892.

A

CATALOGUE OF BOOKS

INCLUDING NEW AND STANDARD WORKS IN

ENGINEERING: CIVIL, MECHANICAL, AND MARINE,
MINING AND METALLURGY,
ELECTRICITY AND ELECTRICAL ENGINEERING,
ARCHITECTURE AND BUILDING,
INDUSTRIAL AND DECORATIVE ARTS, SCIENCE, TRADE
AGRICULTURE, GARDENING,
LAND AND ESTATE MANAGEMENT, LAW, &c.

PUBLISHED BY

CROSBY LOCKWOOD & SON.

MECHANICAL ENGINEERING, etc.

New Pocket-Book for Mechanical Engineers.

THE MECHANICAL ENGINEER'S POCKET-BOOK OF TABLES, FORMULÆ, RULES AND DATA. A Handy Book of Reference for Daily Use in Engineering Practice. By D. KINNEAR CLARK, M.Inst.C.E., Author of "Railway Machinery," "Tramways," &c. &c. Small 8vo, nearly 700 pages. With Illustrations. Rounded edges, cloth limp, 7*s.* 6*d.*; or leather, gilt edges, 9*s.* [*Just published.*

New Manual for Practical Engineers.

THE PRACTICAL ENGINEER'S HAND-BOOK. Comprising a Treatise on Modern Engines and Boilers: Marine, Locomotive and Stationary. And containing a large collection of Rules and Practical Data relating to recent Practice in Designing and Constructing all kinds of Engines, Boilers, and other Engineering work. The whole constituting a comprehensive Key to the Board of Trade and other Examinations for Certificates of Competency in Modern Mechanical Engineering. By WALTER S. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook for Engineers," &c. With upwards of 370 Illustrations. Fourth Edition, Revised, with Additions. Medium 8vo, nearly 500 pp., price 18*s.* Strongly bound. [*Just published.*

☞ *This work is designed as a companion to the Author's* "WORKS' MANAGER'S HAND-BOOK." *It possesses many new and original features, and contains, like its predecessor, a quantity of matter not originally intended for publication, but collected by the author for his own use in the construction of a great variety of modern engineering work.*

*** OPINIONS OF THE PRESS.

"A thoroughly good practical handbook, which no engineer can go through without learning something that will be of service to him."—*Marine Engineer.*

"An excellent book of reference for engineers, and a valuable text-book for students of engineering."—*Scotsman.*

"This valuable manual embodies the results and experience of the leading authorities on mechanical engineering."—*Building News.*

"The author has collected together a surprising quantity o. rules and practical data, and has shown much judgment in the selections he has made. . . . There is no doubt that this book is one of the most useful of its kind published, and will be a very popular compendium."—*Engineer.*

"A mass of information, set down in simple language, and in such a form that it can be easily referred to at any time. The matter is uniformly good and well chosen, and is greatly elucidated by the illustrations. The book will find its way on to most engineers' shelves, where it will rank as one of the most useful books of reference."—*Practical Engineer.*

"Should be found on the office shelf of all practical engineers."—*English Mechanic.*

Handbook for Works' Managers.

THE WORKS' MANAGER'S HANDBOOK OF MODERN RULES, TABLES, AND DATA. For Engineers, Millwrights, and Boiler Makers; Tool Makers, Machinists, and Metal Workers; Iron and Brass Founders, &c. By W. S. HUTTON, C.E., Author of "The Practical Engineer's Handbook." Fourth Edition, carefully Revised, and partly Re-written. In One handsome Volume, medium 8vo, 15s. strongly bound. [*Just published.*

☞ *The Author having compiled Rules and Data for his own use in a great variety of modern engineering work, and having found his notes extremely useful, decided to publish them—revised to date—believing that a practical work, suited to the* DAILY REQUIREMENTS OF MODERN ENGINEERS, *would be favourably received.*

In the Third Edition, the following among other additions have been made, viz.: Rules for the Proportions of Riveted Joints in Soft Steel Plates, the Results of Experiments by PROFESSOR KENNEDY *for the Institution of Mechanical Engineers—Rules for the Proportions of Turbines—Rules for the Strength of Hollow Shafts of Whitworth's Compressed Steel, &c.*

*** OPINIONS OF THE PRESS.

"The author treats every subject from the point of view of one who has collected workshop notes for application in workshop practice, rather than from the theoretical or literary aspect. The volume contains a great deal of that kind of information which is gained only by practical experience, and is seldom written in books."—*Engineer.*

"The volume is an exceedingly useful one, brimful with engineers' notes, memoranda, and rules, and well worthy of being on every mechanical engineer's bookshelf."—*Mechanical World.*

"The information is precisely that likely to be required in practice. . . . The work forms a desirable addition to the library not only of the works manager, but of anyone connected with general engineering."—*Mining Journal.*

"A formidable mass of facts and figures, readily accessible through an elaborate index . . . . Such a volume will be found absolutely necessary as a book of reference in all sorts of 'works' connected with the metal trades."—*Ryland's Iron Trades Circular.*

"Brimful of useful information, stated in a concise form, Mr. Hutton's books have met a pressing want among engineers. The book must prove extremely useful to every practical man possessing a copy."—*Practical Engineer.*

Practical Treatise on Modern Steam-Boilers.

STEAM-BOILER CONSTRUCTION. A Practical Handbook for Engineers, Boiler-Makers, and Steam Users. Containing a large Collection of Rules and Data relating to the Design, Construction, and Working of Modern Stationary, Locomotive, and Marine Steam-Boilers. By WALTER S. HUTTON, C.E., Author of "The Works' Manager's Handbook," &c. With upwards of 300 Illustrations. Medium 8vo, 18s. cloth. [*Just published.*

"Every detail, both in boiler design and management, is clearly laid before the reader. The volume shows that boiler construction has been reduced to the condition of one of the most exact sciences; and such a book is of the utmost value to the *fin de siècle* Engineer and Works' Manager."—*Marine Engineer.*

"There has long been room for a modern handbook on steam boilers; there is not that room now, because Mr. Hutton has filled it. It is a thoroughly practical book for those who are occupied in the construction, design, se'ection, or use of boilers."—*Engineer.*

"The Modernised Templeton."

THE PRACTICAL MECHANIC'S WORKSHOP COMPANION. Comprising a great variety of the most useful Rules and Formulæ in Mechanical Science, with numerous Tables of Practical Data and Calculated Results for Facilitating Mechanical Operations. By WILLIAM TEMPLETON, Author of "The Engineer's Practical Assistant," &c. &c. Sixteenth Edition, Revised, Modernised, and considerably Enlarged by WALTER S. HUTTON, C.E., Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. Fcap. 8vo, nearly 500 pp., with Eight Plates and upwards of 250 Illustrative Diagrams, 6s., strongly bound for workshop or pocket wear and tear. [*Just published.*

*** OPINIONS OF THE PRESS.

"In its modernised form Hutton's 'Templeton' should have a wide sale, for it contains much valuable information which the mechanic will often find of use, and not a few tables and notes which he might look for in vain in other works. This modernised edition wi be appreciated by all who have learned to value the original editions of 'Templeton.'"—*English Mechanic.*

"It has met with great success in the engineering workshop, as we can testify; and there are a great many men who, in a great measure, owe their rise in life to this little book."—*Building News.*

"This familiar text-book—well known to all mechanics and engineers—is of essential service to the every-day requirements of engineers, millwrights, and the various trades connected with engineering and building. The new modernised edition is worth its weight in gold."—*Building News.* (Second Notice.)

"This well-known and largely-used book contains information, brought up to date, of the sort so useful to the foreman and draughtsman. So much fresh information has been introduced as to constitute it practically a new book. It will be largely used in the office and workshop."—*Mechanical World.*

Stone-working Machinery.

STONE-WORKING MACHINERY, and the Rapid and Economical Conversion of Stone. With Hints on the Arrangement and Management of Stone Works. By M. POWIS BALE, M.I.M.E. With Illusts. Crown 8vo, 9s.

"Should be in the hands of every mason or student of stone-work."—*Colliery Guardian.*

"A capital handbook for all who manipulate stone for building or ornamental purposes."—*Machinery Market.*

Pump Construction and Management.

PUMPS AND PUMPING : A Handbook for Pump Users. Being Notes on Selection, Construction and Management. By M. POWIS BALE, M.I.M.E., Author of "Woodworking Machinery," &c. Crown 8vo, 2s. 6d.

"The matter is set forth as concisely as possible. In fact, condensation rather than diffuseness has been the author's aim throughout; yet he does not seem to have omitted anything likely to be of use."—*Journal of Gas Lighting.*

Milling Machinery, etc.

MILLING MACHINES AND PROCESSES : A Practical Treatise on Shaping Metals by Rotary Cutters, including Information on Making and Grinding the Cutters. By PAUL N. HASLUCK, Author of "Lathe-work." With upwards of 300 Engravings. Large crown 8vo, 12s. 6d. cloth. [*Just published.*

Turning.

LATHE-WORK : A Practical Treatise on the Tools, Appliances, and Processes employed in the Art of Turning. By PAUL N. HASLUCK. Fourth Edition, Revised and Enlarged. Cr. 8vo, 5s. cloth.

"Written by a man who knows, not only how work ought to be done, but who also knows how to do it, and how to convey his knowledge to others. To all turners this book would be valuable." —*Engineering.*

"We can safely recommend the work to young engineers. To the amateur it will simply be invaluable. To the student it will convey a great deal of useful information."—*Engineer.*

Screw-Cutting.

SCREW THREADS : And Methods of Producing Them. With Numerous Tables, and complete directions for using Screw-Cutting Lathes. By PAUL N. HASLUCK, Author of "Lathe-Work," &c. With Fifty Illustrations. Third Edition, Enlarged. Waistcoat-pocket size, 1s. 6d. cloth.

"Full of useful information, hints and practical criticism. Taps, dies and screwing-tools generally are illustrated and their action described."—*Mechanical World.*

"It is a complete compendium of all the details of the screw-cutting lathe; in fact a *multum-in-parvo* on all the subjects it treats upon."—*Carpenter and Builder.*

Smith's Tables for Mechanics, etc.

TABLES, MEMORANDA, AND CALCULATED RESULTS, FOR MECHANICS, ENGINEERS, ARCHITECTS, BUILDERS, etc. Selected and Arranged by FRANCIS SMITH. Fifth Edition, thoroughly Revised and Enlarged, with a New Section of ELECTRICAL TABLES, FORMULÆ, and MEMORANDA. Waistcoat-pocket size, 1s. 6d. limp leather. [*Just published.*

"It would, perhaps, be as difficult to make a small pocket-book selection of notes and formulæ to suit ALL engineers as it would be to make a universal medicine; but Mr. Smith's waistcoat-pocket collection may be looked upon as a successful attempt."—*Engineer.*

"The best example we have ever seen of 250 pages of useful matter packed into the dimensions of a card-case."—*Building News.* "A veritable pocket treasury of knowledge."—*Iron.*

Engineer's and Machinist's Assistant.

THE ENGINEER'S, MILLWRIGHT'S, and MACHINIST'S PRACTICAL ASSISTANT. A collection of Useful Tables, Rules and Data. By WILLIAM TEMPLETON. 7th Edition, with Additions. 18mo, 2s. 6d. cloth.

"Occupies a foremost place among books of this kind. A more suitable present to an apprentice to any of the mechanical trades could not possibly be made."—*Building News.*

"A deservedly popular work, it should be in the 'drawer' of every mechanic."—*English Mechanic.*

Iron and Steel.

"IRON AND STEEL" : A Work for the Forge, Foundry, Factory, and Office. Containing ready, useful, and trustworthy Information for Ironmasters; Managers of Bar, Rail, Plate, and Sheet Rolling Mills; Iron and Metal Founders; Iron Ship and Bridge Builders; Mecnanical, Mining, and Consulting Engineers; Contractors, Builders, &c. By CHARLES HOARE. Eighth Edition, Revised and considerably Enlarged. 32mo, 6s. leather.

"One of the best of the pocket books."—*English Mechanic.*

"We cordially recommend this book to those engaged in considering the details of all kinds of iron and steel works."—*Naval Science.*

Engineering Construction.

PATTERN-MAKING: A Practical Treatise, embracing the Main Types of Engineering Construction, and including Gearing, both Hand and Machine made, Engine Work, Sheaves and Pulleys, Pipes and Columns, Screws, Machine Parts, Pumps and Cocks, the Moulding of Patterns in Loam and Greensand, &c., together with the methods of Estimating the weight of Castings; to which is added an Appendix of Tables for Workshop Reference. By a FOREMAN PATTERN MAKER. With upwards of Three Hundred and Seventy Illustrations. Crown 8vo, 7*s*. 6*d*. cloth.

"A well-written technical guide, evidently written by a man who understands and has practised what he has written about. . . . We cordially recommend it to engineering students, young journeymen, and others desirous of being initiated into the mysteries of pattern-making."—*Builder.*

"We can confidently recommend this comprehensive treatise.'—*Building News.*

"Likely to prove a welcome guide to many workmen, especially to draughtsmen who have lacked a training in the shops, pupils pursuing their practical studies in our factories, and to employers and managers in engineering works."—*Hardware Trade Journal.*

"More than 370 illustrations help to explain the text, which is, however, always clear and explicit, thus rendering the work an excellent *vade mecum* for the apprentice who desires to become master of his trade."—*English Mechanic.*

Dictionary of Mechanical Engineering Terms.

LOCKWOOD'S DICTIONARY OF TERMS USED IN THE PRACTICE OF MECHANICAL ENGINEERING, embracing those current in the Drawing Office, Pattern Shop, Foundry, Fitting, Turning, Smith's and Boiler Shops, &c. &c. Comprising upwards of 6,000 Definitions. Edited by A FOREMAN PATTERN-MAKER, Author of "Pattern Making." Crown 8vo, 7*s*. 6*d*. cloth.

"Just the sort of handy dictionary required by the various trades engaged in mechanical engineering. The practical engineering pupil will find the book of great value in his studies, and every foreman engineer and mechanic should have a copy."—*Building News.*

"After a careful examination of the book, and trying all manner of words, we think that the engineer will here find all he is likely to require. It will be largely used."—*Practical Engineer.*

"One of the most useful books which can be presented to a mechanic or student."—*English Mechanic.*

"Not merely a dictionary, but, to a certain extent, also a most valuable guide. It strikes us as a happy idea to combine with a definition of the phrase useful information on the subject of which it treats."—*Machinery Market.*

"No word having connection with any branch of constructive engineering seems to be omitted. No more comprehensive work has been, so far, issued. —*Knowledge.*

"We strongly commend this useful and reliable adviser to our friends in the workshop, and to students everywhere."—*Colliery Guardian.*

Steam Boilers.

A TREATISE ON STEAM BOILERS: Their Strength, Construction, and Economical Working. By ROBERT WILSON, C.E. Fifth Edition. 12mo, 6*s*. cloth.

"The best treatise that has ever been published on steam boilers."—*Engineer.*

"The author shows himself perfect master of his subject, and we heartily recommend all employing steam power to possess themselves of the work."—*Ryland's Iron Trade Circular.*

Boiler Chimneys.

BOILER AND FACTORY CHIMNEYS; Their Draught-Power and Stability. With a Chapter on *Lightning Conductors.* By ROBERT WILSON, A.I.C.E., Author of "A Treatise on Steam Boilers," &c. Second Edition. Crown 8vo, 3*s*. 6*d*. cloth.

"Full of useful information, definite in statement, and thoroughly practical in treatment. —*The Local Government Chronicle.*

"A valuable contribution to the iterature of scientific building."—*The Builder.*

Boiler Making.

THE BOILER-MAKER'S READY RECKONER & ASSISTANT. With Examples of Practical Geometry and Templating, for the Use of Platers, Smiths and Riveters. By JOHN COURTNEY, Edited by D. K. CLARK, M.I.C.E. Third Edition, 480 pp., with 140 Illusts. Fcap. 8vo, 7*s*. half-bound.

"No workman or apprentice should be without this book."—*Iron Trade Circular.*

"Boiler-makers will readily recognise the value of this volume. . . . The tables are clearly printed, and so arranged that they can be referred to with the greatest facility, so that it cannot be doubted that they will be generally appreciated and much used."—*Mining Journal.*

Warming.

HEATING BY HOT WATER; with Information and Suggestions on the best Methods of Heating Public, Private and Horticultural Buildings. By WALTER JONES. With Illustrations, crown 8vo, 2*s*. cloth.

"We confidently recommend all interested in heating by hot water to secure a copy of this valuable little treatise."—*The Plumber and Decorator.*

Steam Engine.

TEXT-BOOK ON THE STEAM ENGINE. With a Supplement on Gas Engines, and PART II. ON HEAT ENGINES. By T. M. GOODEVE, M.A., Barrister-at-Law, Professor ot Mechanics at the Normal School of Science and the Royal School of Mines; Author of "The Principles of Mechanics," "The Elements ot Mechanism," &c. Eleventh Edition, Enlarged. With numerous Illustrations. Crown 8vo, 6*s.* cloth.

"Professor Goodeve has given us a treatise on the steam engine which will bear comparison with anything written by Huxley or Maxwell, and we can award it no higher praise."—*Engineer.*

"Mr. Goodeve's text-book is a work of which every young engineer should possess himself." —*Mining Journal.*

Gas Engines.

ON GAS-ENGINES. Being a Reprint, with some Additions, of the Supplement to the *Text-book on the Steam Engine*, by T. M. GOODEVE, M.A. Crown 8vo, 2*s.* 6*d.* cloth.

"Like all Mr. Goodeve's writings, the present is no exception in point of general excellence. It is a valuable little volume."—*Mechanical World.*

Steam.

THE SAFE USE OF STEAM. Containing Rules for Unprofessional Steam-users. By an ENGINEER. Sixth Edition. Sewed, 6*d.*

"If steam-users would but learn this little book by heart boiler explosions would become sensations by their rarity."—*English Mechanic.*

Reference Book for Mechanical Engineers.

THE MECHANICAL ENGINEER'S REFERENCE BOOK, for Machine and Boiler Construction. In Two Parts. Part I. GENERAL ENGINEERING DATA. Part II. BOILER CONSTRUCTION. With 51 Plates and numerous Illustrations. By NELSON FOLEY, M.I.N.A. Folio, £5 5*s.* half-bound. [*Just published.*

Coal and Speed Tables.

A POCKET BOOK OF COAL AND SPEED TABLES, for Engineers and Steam-users. By NELSON FOLEY, Author of "Boiler Construction." Pocket-size, 3*s.* 6*d.* cloth; 4*s.* leather.

"These tables are designed to meet the requirements of every-day use; and may be commended to engineers and users of steam."—*Iron.*

"This pocket-book well merits the attention of the practical engineer. Mr. Foley has compiled a very useful set of tables, the information contained in which is frequently required by engineers, coal consumers and users of steam."—*Iron and Coal Trades Review.*

Fire Engineering.

FIRES, FIRE-ENGINES, AND FIRE-BRIGADES. With a History of Fire-Engines, their Construction, Use, and Management; Remarks on Fire-Proof Buildings, and the Preservation of Life from Fire; Foreign Fire Systems, &c. By C. F. T. YOUNG, C.E. With numerous Illustrations, 544 pp., demy 8vo, £1 4*s.* cloth.

"To such of our readers as are interested in the subject of fires and fire apparatus, we can most heartily commend this book."—*Engineering.*

"It displays much evidence of careful research; and Mr. Young has put his facts neatly together. It is evident enough that his acquaintance with the practical details of the construction of steam fire engines is accurate and full."—*Engineer.*

Estimating for Engineering Work, &c.

ENGINEERING ESTIMATES, COSTS AND ACCOUNTS: A Guide to Commercial Engineering. With numerous Examples of Estimates and Costs of Millwright Work, Miscellaneous Productions, Steam Engines and Steam Boilers; and a Section on the Preparation of Costs Accounts. By A GENERAL MANAGER. Demy 8vo, 12*s.* cloth.

"This is an excellent and very useful book, covering subject-matter in constant requisition in every factory and workshop. . . . The book is invaluable, not only to the young engineer, but also to the estimate department of every works."—*Builder.*

"We accord the work unqualified praise. The information is given in a plain, straightforward manner, and bears throughout evidence of the intimate practical acquaintance of the author with every phrase of commercial engineering."—*Mechanical World.*

Elementary Mechanics.

CONDENSED MECHANICS. A Selection of Formulæ, Rules, Tables, and Data for the Use of Engineering Students, Science Classes, &c. In Accordance with the Requirements of the Science and Art Department. By W. G. CRAWFORD HUGHES, A.M.I.C.E. Crown 8vo, 2*s.* 6*d.* cloth. [*Just published.*

THE POPULAR WORKS OF MICHAEL REYNOLDS
("THE ENGINE DRIVER'S FRIEND").

Locomotive-Engine Driving.

LOCOMOTIVE-ENGINE DRIVING: A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS, Member of the Society of Engineers, formerly Locomotive Inspector L. B. and S. C. R. Eighth Edition. Including a KEY TO THE LOCOMOTIVE ENGINE. With Illustrations and Portrait of Author. Crown 8vo, 4s. 6d. cloth.

"Mr. Reynolds has supplied a want, and has supplied it well. We can confidently recommend the book, not only to the practical driver, but to everyone who takes an interest in the performance of locomotive engines."—*The Engineer.*

"Mr. Reynolds has opened a new chapter in the literature of the day. This admirable practical treatise, of the practical utility of which we have to speak in terms of warm commendation."—*Athenæum.*

"Evidently the work of one who knows his subject thoroughly."—*Railway Service Gazette.*

"Were the cautions and rules given in the book to become part of the every-day working of our engine-drivers, we might have fewer distressing accidents to deplore."—*Scotsman.*

Stationary Engine Driving.

STATIONARY ENGINE DRIVING: A Practical Manual for Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS. Fourth Edition, Enlarged. With Plates and Woodcuts. Crown 8vo, 4s. 6d. cloth.

"The author is thoroughly acquainted with his subjects, and his advice on the various points treated is clear and practical. . . . He has produced a manual which is an exceedingly useful one for the class for whom it is specially intended."—*Engineering.*

"Our author leaves no stone unturned. He is determined that his readers shall not only know something about the stationary engine, but all about it."—*Engineer.*

"An engineman who has mastered the contents of Mr. Reynolds's book will require but little actual experience with boilers and engines before he can be trusted to look after them."—*English Mechanic.*

The Engineer, Fireman, and Engine-Boy.

THE MODEL LOCOMOTIVE ENGINEER, FIREMAN, and ENGINE-BOY. Comprising a Historical Notice of the Pioneer Locomotive Engines and their Inventors. By MICHAEL REYNOLDS. With numerous Illustrations and a fine Portrait of George Stephenson. Crown 8vo, 4s. 6d. cloth.

"From the technical knowledge of the author it will appeal to the railway man of to-day more forcibly than anything written by Dr. Smiles. . . . The volume contains information of a technical kind, and facts that every driver should be familiar with."—*English Mechanic.*

"We should be glad to see this book in the possession of everyone in the kingdom who has ever laid, or is to lay, hands on a locomotive engine."—*Iron.*

Continuous Railway Brakes.

CONTINUOUS RAILWAY BRAKES: A Practical Treatise on the several Systems in Use in the United Kingdom; their Construction and Performance. With copious Illustrations and numerous Tables. By MICHAEL REYNOLDS. Large crown 8vo, 9s. cloth.

"A popular explanation of the different brakes. It will be of great assistance in forming public opinion, and will be studied with benefit by those who take an interest in the brake."—*English Mechanic.*

"Written with sufficient technical detail to enable the principle and relative connection of the various parts of each particular brake to be readily grasped."—*Mechanical World.*

Engine-Driving Life.

ENGINE-DRIVING LIFE: Stirring Adventures and Incidents in the Lives of Locomotive-Engine Drivers. By MICHAEL REYNOLDS. Second Edition, with Additional Chapters. Crown 8vo. 2s. cloth.

"From first to last perfectly fascinating. Wilkie Collins's most thrilling conceptions are thrown into the shade by true incidents, endless in their variety, related in every page."—*North British Mail.*

"Anyone who wishes to get a real insight into railway life cannot do better than read 'Engine-Driving Life' for himself; and if he once take it up he will find that the author's enthusiasm and real love of the engine-driving profession will carry him on till he has read every page."—*Saturday Review.*

Pocket Companion for Enginemen.

THE ENGINEMAN'S POCKET COMPANION AND PRACTICAL EDUCATOR FOR ENGINEMEN, BOILER ATTENDANTS, AND MECHANICS. By MICHAEL REYNOLDS. With Forty-five Illustrations and numerous Diagrams. Second Edition, Revised. Royal 18mo, 3s. 6d., strongly bound for pocket wear.

"This admirable work is well suited to accomplish its object, being the honest workmanship of a competent engineer."—*Glasgow Herald.*

"A most meritorious work, giving in a succinct and practical form all the information an engine-minder desirous of mastering the scientific principles of his daily calling would require."—*Miller.*

"A boon to those who are striving to become efficient mechanics."—*Daily Chronicle.*

French-English Glossary for Engineers, etc.

A POCKET GLOSSARY of TECHNICAL TERMS: ENGLISH-FRENCH, FRENCH-ENGLISH; with Tables suitable for the Architectural, Engineering, Manufacturing and Nautical Professions. By JOHN JAMES FLETCHER, Engineer and Surveyor. 200 pp. Waistcoat-pocket size, 1*s.* 6*d.*, limp leather.

"It ought certainly to be in the waistcoat-pocket of every professional man."—*Iron.*

"It is a very great advantage for readers and correspondents in France and England to have so large a number of the words relating to engineering and manufacturers collected in a liliputian volume. The little book will be useful both to students and travellers.'—*Architect.*

"The glossary of terms is very complete, and many of the tables are new and well arranged. We cordially commend the book."—*Mechanical World.*

Portable Engines.

THE PORTABLE ENGINE; ITS CONSTRUCTION AND MANAGEMENT. A Practical Manual for Owners and Users of Steam Engines generally. By WILLIAM DYSON WANSBROUGH. With 90 Illustrations. Crown 8vo, 3*s.* 6*d.* cloth.

"This is a work of value to those who use steam machinery. . . . Should be read by every-one who has a steam engine, on a farm or elsewhere."—*Mark Lane Express.*

"We cordially commend this work to buyers and owners of steam engines, and to those who have to do with their construction or use."—*Timber Trades Journal.*

"Such a general knowledge of the steam engine as Mr. Wansbrough furnishes to the reader should be acquired by all intelligent owners and others who use the steam engine."—*Building News.*

"An excellent text-book of this useful form of engine, which describes with all necessary minuteness the details of the various devices. . . 'The Hints to Purchasers contain a good deal of commonsense and practical wisdom."—*English Mechanic.*

CIVIL ENGINEERING, SURVEYING, etc.

MR. HUMBER'S IMPORTANT ENGINEERING BOOKS.

The Water Supply of Cities and Towns.

A COMPREHENSIVE TREATISE on the WATER-SUPPLY OF CITIES AND TOWNS. By WILLIAM HUMBER, A-M.Inst.C.E., and M. Inst. M.E., Author of "Cast and Wrought Iron Bridge Construction," &c. &c. Illustrated with 50 Double Plates, 1 Single Plate, Coloured Frontispiece, and upwards of 250 Woodcuts, and containing 400 pages of Text. Imp. 4to, £6 6*s.* elegantly and substantially half-bound in morocco.

List of Contents.

I. Historical Sketch of some of the means that have been adopted for the Supply of Water to Cities and Towns.—II. Water and the Foreign Matter usually associated with it.—III. Rainfall and Evaporation.—IV. Springs and the water-bearing formations of various districts.—V. Measurement and Estimation of the flow of Water.—VI. On the Selection of the Source of Supply.—VII. Wells.—VIII. Reservoirs.—IX. The Purification of Water.—X. Pumps. — XI. Pumping Machinery. — XII. Conduits.—XIII. Distribution of Water.—XIV. Meters, Service Pipes, and House Fittings.—XV. The Law and Economy of Water Works. XVI. Constant and Intermittent Supply.—XVII. Description of Plates. — Appendices, giving Tables of Rates of Supply, Velocities, &c. &c., together with Specifications of several Works illustrated, among which will be found: Aberdeen, Bideford, Canterbury, Dundee, Halifax, Lambeth, Rotherham, Dublin, and others.

"The most systematic and valuable work upon water supply hitherto produced in English, or in any other language. . . . Mr. Humber's work is characterised almost throughout by an exhaustiveness much more distinctive of French and German than of English technical treatises."—*Engineer.*

"We can congratulate Mr. Humber on having been able to give so large an amount of information on a subject so important as the water supply of cities and towns. The plates, fifty in number, are mostly drawings of executed works, and alone would have commanded the attention of every engineer whose practice may lie in this branch of the profession."—*Builder.*

Cast and Wrought Iron Bridge Construction.

A COMPLETE AND PRACTICAL TREATISE ON CAST AND WROUGHT IRON BRIDGE CONSTRUCTION, including Iron Foundations. In Three Parts—Theoretical, Practical, and Descriptive. By WILLIAM HUMBER, A.M.Inst.C.E., and M.Inst.M.E. Third Edition, Revised and much improved, with 115 Double Plates (20 of which now first appear in this edition), and numerous Additions to the Text. In Two Vols., imp. 4to, £6 16*s.* 6*d.* half-bound in morocco.

"A very valuable contribution to the standard literature of civil engineering. In addition to elevations, plans and sections, large scale details are given which very much enhance the instructive worth of those illustrations."—*Civil Engineer and Architect's Journal.*

"Mr. Humber's stately volumes, lately issued—in which the most important bridges erected during the last five years, under the direction of the late Mr. Brunel, Sir W. Cubitt, Mr. Hawkshaw, Mr. Page, Mr. Fowler, Mr. Hemans, and others among our most eminent engineers, are drawn and specified in great detail."—*Engineer.*

MR. HUMBER'S GREAT WORK ON MODERN ENGINEERING.

Complete in Four Volumes, imperial 4to, price £12 12s., half-morocco. Each Volume sold separately as follows:—

A RECORD OF THE PROGRESS OF MODERN ENGINEERING. FIRST SERIES. Comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, &c. By WILLIAM HUMBER, A-M.Inst.C.E., &c. Imp. 4to, with 36 Double Plates, drawn to a large scale, Photographic Portrait of John Hawkshaw, C.E., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Victoria Station and Roof, L. B. & S. C. R. (8 plates); Southport Pier (2 plates); Victoria Station and Roof, L. C. & D. and G. W. R. (6 plates); Roof of Cremorne Music Hall; Bridge over G. N. Railway; Roof of Station, Dutch Rhenish Rail (2 plates); Bridge over the Thames, West London Extension Railway (5 plates); Armour Plates: Suspension Bridge, Thames (4 plates); The Allen Engine; Suspension Bridge, Avon (3 plates); Underground Railway (3 plates).

"Handsomely lithographed and printed. It will find favour with many who desire to preserve in a permanent form copies of the plans and specifications prepared for the guidance of the contractors for many important engineering works."—*Engineer.*

HUMBER'S RECORD OF MODERN ENGINEERING. SECOND SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of Robert Stephenson, C.E., M.P., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Birkenhead Docks, Low Water Basin (15 plates); Charing Cross Station Roof, C. C. Railway (3 plates); Digswell Viaduct, Great Northern Railway; Robbery Wood Viaduct, Great Northern Railway; Iron Permanent Way; Clydach Viaduct, Merthyr, Tredegar, and Abergavenny Railway; Ebbw Viaduct, Merthyr, Tredegar, and Abergavenny Railway; College Wood Viaduct, Cornwall Railway; Dublin Winter Palace Roof (3 plates); Bridge over the Thames, L. C. & D. Railway (6 plates); Albert Harbour, Greenock (4 plates).

"Mr. Humber has done the profession good and true service, by the fine collection of examples he has here brought before the profession and the public."—*Practical Mechanic's Journal.*

HUMBER'S RECORD OF MODERN ENGINEERING. THIRD SERIES. Imp. 4to, with 40 Double Plates, Photographic Portrait of J. R. M'Clean, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

MAIN DRAINAGE, METROPOLIS.—*North Side.*—Map showing Interception of Sewers; Middle Level Sewer (2 plates); Outfall Sewer, Bridge over River Lea (3 plates); Outfall Sewer, Bridge over Marsh Lane, North Woolwich Railway, and Bow and Barking Railway Junction; Outfall Sewer, Bridge over Bow and Barking Railway (3 plates); Outfall Sewer, Bridge over East London Waterworks' Feeder (2 plates); Outfall Sewer, Reservoir (2 plates); Outfall Sewer, Tumbling Bay and Outlet; Outfall Sewer, Penstocks. *South Side.*—Outfall Sewer, Bermondsey Branch (2 plates); Outfall Sewer, Reservoir and Outlet (4 plates); Outfall Sewer, Filth Hoist; Sections of Sewers (North and South Sides).

THAMES EMBANKMENT.—Section of River Wall; Steamboat Pier, Westminster (2 plates); Landing Stairs between Charing Cross and Waterloo Bridges; York Gate (2 plates); Overflow and Outlet at Savoy Street Sewer (3 plates); Steamboat Pier, Waterloo Bridge (3 plates); Junction of Sewers, Plans and Sections; Gullies, Plans and Sections; Rolling Stock; Granite and Iron Forts.

"The drawings have a constantly increasing value, and whoever desires to possess clear representations of the two great works carried out by our Metropolitan Board will obtain Mr. Humber's volume."—*Engineer.*

HUMBER'S RECORD OF MODERN ENGINEERING. FOURTH SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of John Fowler, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Abbey Mills Pumping Station, Main Drainage, Metropolis (4 plates); Barrow Docks (5 plates); Manquis Viaduct, Santiago and Valparaiso Railway (2 plates); Adam's Locomotive, St. Helen's Canal Railway (2 plates); Cannon Street Station Roof, Charing Cross Railway (3 plates); Road Bridge over the River Moka (2 plates); Telegraphic Apparatus for Mesopotamia; Viaduct over the River Wye, Midland Railway (3 plates); St. Germans Viaduct, Cornwall Railway (2 plates); Wrought-Iron Cylinder for Diving Bell; Millwall Docks (6 plates); Milroy's Patent Excavator; Metropolitan District Railway (6 plates); Harbours, Ports, and Breakwaters (3 plates).

"We gladly welcome another year's issue of this valuable publication from the able pen of Mr. Humber. The accuracy and general excellence of this work are well known, while its usefulness in giving the measurements and details of some of the latest examples of engineering, as carried out by the most eminent men in the profession, cannot be too highly prized."—*Artizan.*

MR. HUMBER'S ENGINEERING BOOKS—continued.

Strains, Calculation of.

A HANDY BOOK FOR THE CALCULATION OF STRAINS IN GIRDERS AND SIMILAR STRUCTURES, AND THEIR STRENGTH. Consisting of Formulæ and Corresponding Diagrams, with numerous details for Practical Application, &c. By WILLIAM HUMBER, A-M.Inst.C.E., &c. Fifth Edition. Crown 8vo, nearly 100 Woodcuts and 3 Plates, 7*s.* 6*d.* cloth

"The formulæ are neatly expressed, and the diagrams good."—*Athenæum.*

"We heartily commend this really *handy* book to our engineer and architect readers."—*English Mechanic.*

Barlow's Strength of Materials, enlarged by Humber

A TREATISE ON THE STRENGTH OF MATERIALS; with Rules for Application in Architecture, the Construction of Suspension Bridges, Railways, &c. By PETER BARLOW, F.R.S. A New Edition, revised by his Sons, P. W. BARLOW, F.R.S., and W. H. BARLOW, F.R.S.; to which are added, Experiments by HODGKINSON, FAIRBAIRN, and KIRKALDY; and Formulæ for Calculating Girders, &c. Arranged and Edited by W. HUMBER, A-M.Inst.C.E. Demy 8vo, 400 pp., with 19 large Plates and numerous Woodcuts, 18*s.* cloth.

"Valuable alike to the student, tyro, and the experienced practitioner, it will always rank in future, as it has hitherto done, as the standard treatise on that particular subject."—*Engineer.*

"There is no greater authority than Barlow."—*Building News.*

"As a scientific work of the first class, it deserves a foremost place on the bookshelves of every civil engineer and practical mechanic."—*English Mechanic.*

Trigonometrical Surveying.

AN OUTLINE OF THE METHOD OF CONDUCTING A TRIGONOMETRICAL SURVEY, for the Formation of Geographical and Topographical Maps and Plans, Military Reconnaissance, Levelling, &c., with Useful Problems, Formulæ, and Tables. By Lieut.-General FROME, R.E. Fourth Edition, Revised and partly Re-written by Major General Sir CHARLES WARREN, G.C.M.G., R.E. With 19 Plates and 115 Woodcuts, royal 8vo, 16*s.* cloth.

"The simple fact that a fourth edition has been called for is the best testimony to its merits. No words of praise from us can strengthen the position so well and so steadily maintained by this work. Sir Charles Warren has revised the entire work, and made such additions as were necessary to bring every portion of the contents up to the present date."—*Broad Arrow.*

Field Fortification.

A TREATISE ON FIELD FORTIFICATION, THE ATTACK OF FORTRESSES, MILITARY MINING, AND RECONNOITRING. By Colonel I. S. MACAULAY, late Professor of Fortification in the R.M.A., Woolwich. Sixth Edition, crown 8vo, cloth, with separate Atlas of 12 Plates, 12*s.*

Oblique Bridges.

A PRACTICAL AND THEORETICAL ESSAY ON OBLIQUE BRIDGES. With 13 large Plates. By the late GEORGE WATSON BUCK, M.I.C.E. Third Edition, revised by his Son, J. H. WATSON BUCK, M.I.C.E.; and with the addition of Description to Diagrams for Facilitating the Construction of Oblique Bridges, by W. H. BARLOW, M.I.C.E. Royal 8vo, 12*s.* cloth.

"The standard text-book for all engineers regarding skew arches is Mr. Buck's treatise, and would be impossible to consult a better."—*Engineer.*

"Mr. Buck's treatise is recognised as a standard text-book, and his treatment has divested the subject of many of the intricacies supposed to belong to it. As a guide to the engineer and architect, on a confessedly difficult subject, Mr. Buck's work is unsurpassed."—*Building News.*

Water Storage, Conveyance and Utilisation.

WATER ENGINEERING: A Practical Treatise on the Measurement, Storage, Conveyance and Utilisation of Water for the Supply of Towns, for Mill Power, and for other Purposes. By CHARLES SLAGG, Water and Drainage Engineer, A.M.Inst.C.E., Author of "Sanitary Work in the Smaller Towns, and in Villages," &c. With numerous Illusts. Cr. 8vo, 7*s.* 6*d.* cloth.

"As a small practical treatise on the water supply of towns, and on some applications of water-power, the work is in many respects excellent."—*Engineering.*

"The author has collated the results deduced from the experiments of the most eminent authorities, and has presented them in a compact and practical form, accompanied by very clear and detailed explanations. . . . The application of water as a motive power is treated very carefully and exhaustively."—*Builder.*

"For anyone who desires to begin the study of hydraulics with a consideration of the practical applications of the science there is no better guide."—*Architect.*

Statics, Graphic and Analytic.

GRAPHIC AND ANALYTIC STATICS, in their Practical Application to the Treatment of Stresses in Roofs, Solid Girders, Lattice, Bowstring and Suspension Bridges, Braced Iron Arches and Piers, and other Frameworks. By R. HUDSON GRAHAM, C.E. Containing Diagrams and Plates to Scale. With numerous Examples, many taken from existing Structures. Specially arranged for Class-work in Colleges and Universities. Second Edition, Revised and Enlarged. 8vo, 16s. cloth.

"Mr. Graham's book will find a place wherever graphic and analytic statics are used or studied." —*Engineer.*

"The work is excellent from a practical point of view, and has evidently been prepared with much care. The directions for working are ample, and are illustrated by an abundance of well-selected examples. It is an excellent text-book for the practical draughtsman."—*Athenæum.*

Student's Text-Book on Surveying.

PRACTICAL SURVEYING: A Text-Book for Students preparing for Examination or for Survey-work in the Colonies. By GEORGE W. USILL, A.M.I.C.E., Author of "The Statistics of the Water Supply of Great Britain." With Four Lithographic Plates and upwards of 330 Illustrations. Second Edition, Revised. Crown 8vo, 7s. 6d. cloth.

"The best forms of instruments are described as to their construction, uses and modes of employment, and there are innumerable hints on work and equipment such as the author, in his experience as surveyor, draughtsman and teacher, has found necessary, and which the student in his inexperience will find most serviceable."—*Engineer.*

"The latest treatise in the English language on surveying, and we have no hesitation in saying that the student will find it a better guide than any of its predecessors . . . . Deserves to be recognised as the first book which should be put in the hands of a pupil of Civil Engineering, and every gentleman of education who sets out for the Colonies would find it well to have a copy."—*Architect.*

"A very useful, practical handbook on field practice. Clear, accurate and not too condensed."—*Journal of Education.*

Survey Practice.

AID TO SURVEY PRACTICE, for Reference in Surveying, Levelling, and Setting-out; and in Route Surveys of Travellers by Land and Sea. With Tables, Illustrations, and Records. By LOWIS D'A. JACKSON, A.M.I.C.E., Author of "Hydraulic Manual," "Modern Metrology," &c. Second Edition, Enlarged. Large crown 8vo, 12s. 6d. cloth.

"Mr. Jackson has produced a valuable *vade-mecum* for the surveyor. We can recommend this book as containing an admirable supplement to the teaching of the accomplished surveyor."—*Athenæum.*

"As a text-book we should advise all surveyors to place it in their libraries, and study well the matured instructions afforded in its pages."—*Colliery Guardian.*

"The author brings to his work a fortunate union of theory and practical experience which, aided by a clear and lucid style of writing, renders the book a very useful one."—*Builder.*

Surveying, Land and Marine.

LAND AND MARINE SURVEYING, in Reference to the Preparation of Plans for Roads and Railways; Canals, Rivers, Towns' Water Supplies; Docks and Harbours. With Description and Use of Surveying Instruments. By W. D. HASKOLL, C.E., Author of "Bridge and Viaduct Construction," &c. Second Edition, Revised, with Additions. Large cr. 8vo, 9s. cl.

"This book must prove of great value to the student. We have no hesitation in recommending it, feeling assured that it will more than repay a careful study."—*Mechanical World.*

"A most useful and well arranged book for the aid of a student. We can strongly recommend it as a carefully-written and valuable text-book. It enjoys a well-deserved repute among surveyors." —*Builder.*

"This volume cannot fail to prove of the utmost practical utility. It may be safely recommended to all students who aspire to become clean and expert surveyors."—*Mining Journal.*

Tunnelling.

PRACTICAL TUNNELLING. Explaining in detail the Setting-out of the works, Shaft-sinking and Heading-driving, Ranging the Lines and Levelling underground, Sub-Excavating, Timbering, and the Construction of the Brickwork of Tunnels, with the amount of Labour required for, and the Cost of, the various portions of the work. By FREDERICK W. SIMMS, F.G.S., M.Inst.C.E. Third Edition, Revised and Extended by D. KINNEAR CLARK, M.Inst.C.E. Imperial 8vo, with 21 Folding Plates and numerous Wood Engravings, 30s. cloth.

"The estimation in which Mr. Simms's book on tunnelling has been held for over thirty years cannot be more truly expressed than in the words of the late Prof. Rankine:—'The best source of information on the subject of tunnels is Mr. F. W. Simms's work on Practical Tunnelling.'"—*Architect.*

"It has been regarded from the first as a text book of the subject. . . . Mr. Clarke has added immensely to the value of the book."—*Engineer.*

Levelling.

A TREATISE ON THE PRINCIPLES AND PRACTICE OF LEVELLING. Showing its Application to purposes of Railway and Civil Engineering, in the Construction of Roads; with Mr. TELFORD'S Rules for the same. By FREDERICK W. SIMMS, F.G.S., M.Inst.C.E. Seventh Edition, with the addition of LAW'S Practical Examples for Setting-out Railway Curves, and TRAUTWINE'S Field Practice of Laying-out Circular Curves. With 7 Plates and numerous Woodcuts, 8vo, 8*s.* 6*d.* cloth. *** TRAUTWINE on Curves may be had separate, 5*s.*

"The text-book on levelling in most of our engineering schools and colleges."—*Engineer.*

"The publishers have rendered a substantial service to the profession, especially to the younger members, by bringing out the present edition of Mr. Simms's useful work."—*Engineering.*

Heat, Expansion by.

EXPANSION OF STRUCTURES BY HEAT. By JOHN KEILY, C.E., late of the Indian Public Works and Victorian Railway Departments. Crown 8vo, 3*s.* 6*d.* cloth.

SUMMARY OF CONTENTS.

Section I. FORMULAS AND DATA.	Section VI. MECHANICAL FORCE OF HEAT.
Section II. METAL BARS.	Section VII. WORK OF EXPANSION AND CONTRACTION.
Section III. SIMPLE FRAMES.	Section VIII. SUSPENSION BRIDGES.
Section IV. COMPLEX FRAMES AND PLATES.	Section IX. MASONRY STRUCTURES.
Section V. THERMAL CONDUCTIVITY.	

"The aim the author has set before him, viz., to show the effects of heat upon metallic and other structures, is a laudable one, for this is a branch of physics upon which the engineer or architect can find but little reliable and comprehensive data in books."—*Builder.*

"Whoever is concerned to know the effect of changes of temperature on such structures as suspension bridges and the like, could not do better than consult Mr. Keily's valuable and handy exposition of the geometrical principles involved in these changes."—*Scotsman.*

Practical Mathematics.

MATHEMATICS FOR PRACTICAL MEN: Being a Commonplace Book of Pure and Mixed Mathematics. Designed chiefly for the use of Civil Engineers, Architects and Surveyors. By OLINTHUS GREGORY, LL.D., F.R.A.S., Enlarged by HENRY LAW, C.E. 4th Edition, carefully Revised by J. R. YOUNG, formerly Professor of Mathematics, Belfast College. With 13 Plates, 8vo, £1 1*s.* cloth.

"The engineer or architect will here find ready to his hand rules for solving nearly every mathematical difficulty that may arise in his practice The rules are in all cases explained by means of examples, in which every step of the process is clearly worked out."—*Builder.*

"One of the most serviceable books for practical mechanics. . . . It is an instructive book for the student, and a text-book for him who, having once mastered the subjects it treats of, needs occasionally to refresh his memory upon them."—*Building News.*

Hydraulic Tables.

HYDRAULIC TABLES, CO-EFFICIENTS, and FORMULÆ for finding the Discharge of Water from Orifices, Notches, Weirs, Pipes, and Rivers. With New Formulæ, Tables, and General Information on Rainfall, Catchment-Basins, Drainage, Sewerage, Water Supply for Towns and Mill Power. By JOHN NEVILLE, Civil Engineer, M.R.I.A. Third Ed., carefully Revised, with considerable Additions. Numerous Illusts. Cr. 8vo, 14*s.* cloth.

"Alike valuable to students and engineers in practice; its study will prevent the annoyance of avoidable failures, and assist them to select the readiest means of successfully carrying out any given work connected with hydraulic engineering."—*Mining Journal.*

"It is, of all English books on the subject, the one nearest to completeness. . . . From the good arrangement of the matter, the clear expl.anations, and abundance of formulæ, the carefully calculated tables, and, above all, the thorough, acquaintance with both theory and construction, which is displayed from first to last, the book w be found to be an acquisition."—*Architect.*

Hydraulics.

HYDRAULIC MANUAL. Consisting of Working Tables and Explanatory Text. Intended as a Guide in Hydraulic Calculations and Field Operations. By LOWIS D'A. JACKSON, Author of "Aid to Survey Practice," "Modern Metrology," &c. Fourth Edition, Enlarged. Large cr. 8vo, 16*s.* cl.

"The author has had a wide experience in hydraulic engineering and has been a careful observer of the facts which have come under his notice, and from the great mass of material at his command he has constructed a manual which may be accepted as a trustworthy guide to this branch of the engineer's profession. We can heartily recommend this volume to all who desire to be acquainted with the latest development of this important subject."—*Engineering.*

"The standard-work in this department of mechnnics.'—*Scotsman.*

"The most useful feature of this work is its freedom from what is superannuated, and its thorough adoption of recent experiments; the text is, in fact, in great part a short account of the great modern experiments."—*Nature.*

Drainage.

ON THE DRAINAGE OF LANDS, TOWNS AND BUILDINGS. By G. D. DEMPSEY, C.E., Author of "The Practical Railway Engineer," &c. Revised, with large Additions on RECENT PRACTICE IN DRAINAGE ENGINEERING, by D. KINNEAR CLARK, M.Inst.C.E. Author of "Tramways," "A Manual of Rules, Tables, and Data for Engineers," &c. Second Edition. 12mo, 5s. cloth.

"The new matter added to Mr. Dempsey's excellent work is characterised by the comprehensive grasp and accuracy of detail for which the name of Mr. D. K. Clark is a sufficient voucher."—*Athenæum.*

"As a work on recent practice in drainage engineering, the book is to be commended to all who are making that branch of engineering science their special study."—*Iron.*

"A comprehensive manual on drainage engineering, and a useful introduction to the student." *Building News.*

Tramways and their Working.

TRAMWAYS: THEIR CONSTRUCTION AND WORKING. Embracing a Comprehensive History of the System; with an exhaustive Analysis of the various Modes of Traction, including Horse-Power, Steam, Heated Water, and Compressed Air; a Description of the Varieties of Rolling Stock; and ample Details of Cost and Working Expenses: the Progress recently made in Tramway Construction, &c. &c. By D. KINNEAR CLARK, M.Inst.C.E. With over 200 Wood Engravings, and 13 Folding Plates. Two Vols., large crown 8vo, 30s. cloth.

"All interested in tramways must refer to it, as all railway engineers have turned to the author's work 'Railway Machinery.'"—*Engineer.*

"An exhaustive and practical work on tramways, in which the history of this kind of locomotion, and a description and cost of the various modes of laying tramways, are to be found."—*Building News.*

"The best form of rails, the best mode of construction, and the best mechanical appliances are so fairly indicated in the work under review, that any engineer about to construct a tramway will be enabled at once to obtain the practical information which will be of most service to him.'—*Athenæum.*

Oblique Arches.

A PRACTICAL TREATISE ON THE CONSTRUCTION OF OBLIQUE ARCHES. By JOHN HART. Third Edition, with Plates. Imperial 8vo, 8s. cloth.

Curves, Tables for Setting-out.

TABLES OF TANGENTIAL ANGLES AND MULTIPLES for Setting-out Curves from 5 *to* 200 *Radius.* By ALEXANDER BEAZELEY, M.Inst.C.E. Third Edition. Printed on 48 Cards, and sold in a cloth box, waistcoat-pocket size, 3s. 6*d.*

"Each table is printed on a small card, which, being placed on the theodolite, leaves the hands free to manipulate the instrument—no small advantage as regards the rapidity of work."—*Engineer.*

"Very handy; a man may know that all his day's work must fall on two of these cards, which he puts into his own card-case, and leaves the rest behind."—*Athenæum.*

Earthwork.

EARTHWORK TABLES. Showing the Contents in Cubic Yards of Embankments, Cuttings, &c., of Heights or Depths up to an average of 80 feet. By JOSEPH BROADBENT, C.E., and FRANCIS CAMPIN, C.E. Crown 8vo, 5s. cloth.

"The way in which accuracy is attained, by a simple division of each cross section into three elements, two in which are constant and one variable, is ingenious."—*Athenæum.*

Tunnel Shafts.

THE CONSTRUCTION OF LARGE TUNNEL SHAFTS: A Practical and Theoretical Essay. By J. H. WATSON BUCK, M.Inst.C.E., Resident Engineer, London and North-Western Railway. Illustrated with Folding Plates, royal 8vo, 12s. cloth.

"Many of the methods given are of extreme practical value to the mason; and the observations on the form of arch, the rules for ordering the stone, and the construction of the templates will be found of considerable use. We commend the book to the engineering profession."—*Building News.*

"Will be regarded by civil engineers as of the utmost value, and calculated to save much time and obviate many mistakes."—*Colliery Guardian.*

Girders, Strength of.

GRAPHIC TABLE FOR FACILITATING THE COMPUTATION OF THE WEIGHTS OF WROUGHT IRON AND STEEL GIRDERS, etc., for Parliamentary and other Estimates. By J. H. WATSON BUCK, M.Inst.C.E. On a Sheet, 2s.6*d.*

River Engineering.

RIVER BARS: The Causes of their Formation, and their Treatment by "Induced Tidal Scour;" with a Description of the Successful Reduction by this Method of the Bar at Dublin. By I. J. MANN, Assist. Eng. to the Dublin Port and Docks Board. Royal 8vo, 7*s.* 6*d.* cloth.

"We recommend all interested in harbour works—and, indeed, those concerned in the improvements of rivers generally—to read Mr. Mann's interesting work on the treatment of river bars."—*Engineer.*

Trusses.

TRUSSES OF WOOD AND IRON. Practical Applications of Science in Determining the Stresses, Breaking Weights, Safe Loads, Scantlings, and Details of Construction, with Complete Working Drawings. By WILLIAM GRIFFITHS, Surveyor, Assistant Master, Tranmere School of Science and Art. Oblong 8vo, 4*s.* 6*d.* cloth.

"This handy little book enters so minutely into every detail connected with the construction of roof trusses, that no student need be ignorant of these matters."—*Practical Engineer.*

Railway Working.

SAFE RAILWAY WORKING. A Treatise on Railway Accidents: Their Cause and Prevention; with a Description of Modern Appliances and Systems. By CLEMENT E. STRETTON, C.E., Vice-President and Consulting Engineer, Amalgamated Society of Railway Servants. With Illustrations and Coloured Plates. Second Edition, Enlarged. Crown 8vo, 3*s.* 6*d.* cloth. [*Just published.*

"A book for the engineer, the directors, the managers; and, in short, all who wish for information on railway matters will find a perfect encyclopædia in 'Safe Railway Working.'"—*Railway Review.*

"We commend the remarks on railway signalling to all railway managers, especially where a uniform code and practice is advocated."—*Herepath's Railway Journal.*

"The author may be congratulated on having collected, in a very convenient form, much valuable information on the principal questions affecting the safe working of railways."—*Railway Engineer.*

Field-Book for Engineers.

THE ENGINEER'S, MINING SURVEYOR'S, AND CONTRACTOR'S FIELD-BOOK. Consisting of a Series of Tables, with Rules, Explanations of Systems, and use of Theodolite for Traverse Surveying and Plotting the Work with minute accuracy by means of Straight Edge and Set Square only; Levelling with the Theodolite, Casting-out and Reducing Levels to Datum, and Plotting Sections in the ordinary manner; setting-out Curves with the Theodolite by Tangential Angles and Multiples, with Right and Left-hand Readings of the Instrument: Setting-out Curves without Theodolite, on the System of Tangential Angles by sets of Tangents and Offsets; and Earthwork Tables to 80 feet deep, calculated for every 6 inches in depth. By W. DAVIS HASKOLL, C.E. With numerous Woodcuts. Fourth Edition, Enlarged. Crown 8vo, 12*s.* cloth.

"The book is very handy; the separate tables of sines and tangents to every minute will make it useful for many other purposes, the genuine traverse tables existing all the same."—*Athenæum.*

"Every person engaged in engineering field operations will estimate the importance of such a work and the amount of valuable time which will be saved by reference to a set of reliable tables prepared with the accuracy and fulness of those given in this volume."—*Railway News.*

Earthwork, Measurement of.

A MANUAL ON EARTHWORK. By ALEX. J. S. GRAHAM, C.E. With numerous Diagrams. Second Edition. 18mo, 2*s.* 6*d.* cloth

"A great amount of practical information, very admirably arranged, and available for rough estimates, as well as for the more exact calculations required in the engineer's and contractor's offices."—*Artizan.*

Strains in Ironwork.

THE STRAINS ON STRUCTURES OF IRONWORK; with Practical Remarks on Iron Construction. By F. W. SHEILDS, M.Inst.C.E. Second Edition, with 5 Plates. Royal 8vo, 5*s.* cloth.

The student cannot find a better little book on this subject."—*Engineer.*

Cast Iron and other Metals, Strength of.

A PRACTICAL ESSAY ON THE STRENGTH OF CAST IRON AND OTHER METALS. By THOMAS TREDGOLD, C.E. Fifth Edition, including HODGKINSON'S Experimental Researches. 8vo, 12*s.* cloth.

ARCHITECTURE, BUILDING, etc.

Construction.

THE SCIENCE OF BUILDING: An Elementary Treatise on the Principles of Construction. By E. WYNDHAM TARN, M.A., Architect. Third Edition, Enlarged, with 59 Engravings. Fcap. 8vo, 4s. cloth.

"A very valuable book, which we strongly recommend to all students."—*Builder.*

"No architectural student should be without this handbook."—*Architect.*

Villa Architecture.

A HANDY BOOK OF VILLA ARCHITECTURE: Being a Series of Designs for Villa Residences in various Styles. With Outline Specifications and Estimates. By C. WICKES, Author of "The Spires and Towers of England," &c. 61 Plates, 4to, £1 11s. 6d. half-morocco, gilt edges.

"The whole of the designs bear evidence of their being the work of an artistic architect, and they will prove very valuable and suggestive."—*Building News.*

Text-Book for Architects.

THE ARCHITECT'S GUIDE: Being a Text-Book of Useful Information for Architects, Engineers, Surveyors, Contractors, Clerks of Works, &c. &c. By FREDERICK ROGERS, Architect, Author of "Specifications for Practical Architecture," &c. Second Edition, Revised and Enlarged. With numerous Illustrations. Crown 8vo, 6s. cloth.

"As a text-book of useful information for architects, engineers, surveyors, &c., it would be hard to find a handier or more complete little volume."—*Standard.*

"A young architect could hardly have a better guide-book."—*Timber Trades Journal.*

Taylor and Cresy's Rome.

THE ARCHITECTURAL ANTIQUITIES OF ROME. By the late G. L. TAYLOR, Esq., F.R.I.B.A., and EDWARD CRESY, Esq. New Edition, thoroughly Revised by the Rev. ALEXANDER TAYLOR, M.A. (son of the late G. L. Taylor, Esq.), Fellow of Queen's College, Oxford, and Chaplain of Gray's Inn. Large folio, with 130 Plates, half-bound, £3 3s.

"Taylor and Cresy's work has from its first publication been ranked among those professional books which cannot be bettered. . . . It would be difficult to find examples of drawings, even among those of the most painstaking students of Gothic, more thoroughly worked out than are the one hundred and thirty plates in this volume."—*Architect.*

Linear Perspective.

ARCHITECTURAL PERSPECTIVE: The whole Course and Operations of the Draughtsman in Drawing a Large House in Linear Perspective. Illustrated by 39 Folding Plates. By F. O. FERGUSON. Demy 8vo, 3s. 6d. boards. [*Just published.*

Architectural Drawing.

PRACTICAL RULES ON DRAWING, for the Operative Builder and Young Student in Architecture. By GEORGE PYNE. With 14 Plates, 4to, 7s. 6d. boards.

Sir Wm. Chambers on Civil Architecture.

THE DECORATIVE PART OF CIVIL ARCHITECTURE. By Sir WILLIAM CHAMBERS, F.R.S. With Portrait, Illustrations, Notes, and an Examination of Grecian Architecture, by JOSEPH GWILT, F.S.A. Revised and Edited by W. H. LEEDS, with a Memoir of the Author. 66 Plates, 4to, 21s. cloth.

House Building and Repairing.

THE HOUSE-OWNER'S ESTIMATOR; or, What will it Cost to Build, Alter, or Repair? A Price Book adapted to the Use of Unprofessional People, as well as for the Architectural Surveyor and Builder. By JAMES D. SIMON, A.R.I.B.A. Edited and Revised by FRANCIS T. W. MILLER, A.R.I.B.A. With numerous Illustrations. Fourth Edition, Revised. Crown 8vo, 3s. 6d. cloth.

"In two years it will repay its cost a hundred times over."—*Field.*

Cottages and Villas.

COUNTRY AND SUBURBAN COTTAGES AND VILLAS How to Plan and Build Them. Containing 33 Plates, with Introduction, General Explanations, and Description of each Plate. By JAMES W. BOGUE, Architect, Author of "Domestic Architecture," &c. 4to, 10s. 6d. cloth.

The New Builder's Price Book, 1892.

LOCKWOOD'S BUILDER'S PRICE BOOK FOR 1892. A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers and Contractors. *Re-constructed, Re-written and Further Enlarged.* By FRANCIS T. W. MILLER. 700 closely-printed pages, crown 8vo, 4*s*. cloth. [*Just published.*

"This book is a very useful one, and should find a place in every English office connected with the building and engineering professions."—*Industries.*

"This Price Book has been set up in new type. . . . Advantage has been taken of the transformation to add much additional information, and the volume is now an excellent book of reference."—*Architect.*

"In its new and revised form this Price Book is what a work of this kind should be—comprehensive, reliable, well arranged, legible and well bound."—*British Architect.*

"A work of established reputation."—*Athenæum.*

"This very useful handbook is well written, exceedingly clear in its explanations and great care has evidently been taken to ensure accuracy."—*Morning Advertiser.*

Designing, Measuring, and Valuing.

THE STUDENT'S GUIDE to the PRACTICE of MEASURING AND VALUING ARTIFICERS' WORKS. Containing Directions for taking Dimensions, Abstracting the same, and bringing the Quantities into Bill, with Tables of Constants for Valuation of Labour, and for the Calculation of Areas and Solidities. Originally edited by EDWARD DOBSON, Architect. With Additions on Mensuration and Construction, and a New Chapter on Dilapidations, Repairs, and Contracts, by E. WYNDHAM TARN, M.A. Sixth Edition, including a Complete Form of a Bill of Quantities. With 8 Plates and 63 Woodcuts. Crown 8vo, 7*s*. 6*d*. cloth.

"Well fulfils the promise of its title-page, and we can thoroughly recommend it to the class for whose use it has been compiled. Mr. Tarn's additions and revisions have much increased the usefulness of the work, and have especially augmented its value to students."—*Engineering.*

"This edition will be found the most complete treatise on the principles of measuring and valuing artificers' work that has yet been published."—*Building News.*

Pocket Estimator and Technical Guide.

THE POCKET TECHNICAL GUIDE, MEASURER AND ESTIMATOR FOR BUILDERS AND SURVEYORS. Containing Technical Directions for Measuring Work in all the Building Trades, Complete Specifications for Houses, Roads, and Drains, and an easy Method of Estimating the parts of a Building collectively. By A. C. BEATON, Author of "Quantities and Measurements," &c. Sixth Edition, Revised. With 53 Woodcuts, waistcoat-pocket size, 1*s*. 6*d*. gilt edges. [*Just published.*

"No builder, architect, surveyor, or valuer should be without his 'Beaton.'"—*Building News.*

"Contains an extraordinary amount of information in daily requisition in measuring and estimating. Its presence in the pocket will save valuable time and trouble."—*Building World.*

Donaldson on Specifications.

THE HANDBOOK OF SPECIFICATIONS; or, Practical Guide to the Architect, Engineer, Surveyor, and Builder, in drawing up Specifications and Contracts for Works and Constructions. Illustrated by Precedents of Buildings actually executed by eminent Architects and Engineers. By Professor T. L. DONALDSON, P.R.I.B.A., &c. New Edition, in One large Vol., 8vo, with upwards of 1,000 pages of Text, and 33 Plates, £1 11*s*. 6*d*. cloth.

"In this work forty-four specifications of executed works are given, including the specifications for parts of the new Houses of Parliament, by Sir Charles Barry, and for the new Royal Exchange, by Mr. Tite, M.P. The latter, in particular, is a very complete and remarkable document. It embodies, to a great extent, as Mr. Donaldson mentions, 'the bill of quantities with the description of the works.' . . . It is valuable as a record, and more valuable still as a book of precedents. . . . Suffice it to say that Donaldson's 'Handbook of Specifications must be bought by all architects."—*Builder.*

Bartholomew and Rogers' Specifications.

SPECIFICATIONS FOR PRACTICAL ARCHITECTURE. A Guide to the Architect, Engineer, Surveyor, and Builder. With an Essay on the Structure and Science of Modern Buildings. Upon the Basis of the Work by ALFRED BARTHOLOMEW, thoroughly Revised, Corrected, and greatly added to by FREDERICK ROGERS, Architect. Second Edition, Revised, with Additions. With numerous Illustrations, medium 8vo, 15*s*. cloth.

"The collection of specifications prepared by Mr. Rogers on the basis of Bartholomew's work is too well known to need any recommendation from us. It is one of the books with which every young architect must be equipped; for time has shown that the specifications cannot be set aside through any defect in them."—*Architect.*

Building ; Civil and Ecclesiastical.

A BOOK ON BUILDING, Civil and Ecclesiastical, including Church Restoration ; with the Theory of Domes and the Great Pyramid, &c. By Sir EDMUND BECKETT, Bart., LL.D., F.R.A.S., Author of "Clocks and Watches, and Bells," &c. Second Edition, Enlarged. Fcap. 8vo, 5s. cloth.

"A book which is always amusing and nearly always instructive. The style throughout is in the highest degree condensed and epigrammatic."—*Times.*

Ventilation of Buildings.

VENTILATION. A Text Book to the Practice of the Art of Ventilating Buildings. With a Chapter upon Air Testing. By W. P. BUCHAN, R.P., Sanitary and Ventilating Engineer, Author of "Plumbing," &c. With 170 Illustrations. 12mo, 4s. cloth boards. [*Just published.*

The Art of Plumbing.

PLUMBING. A Text Book to the Practice of the Art or Craft of the Plumber, with Supplementary Chapters on House Drainage, embodying the latest Improvements. By WILLIAM PATON BUCHAN, R.P., Sanitary Engineer and Practical Plumber. Sixth Edition, Enlarged to 370 pages, and 380 Illustrations. 12mo, 4s. cloth boards.

"A text book which may be safely put in the hands of every young plumber, and which will also be found useful by architects and medical professors."—*Builder.*

"A valuable text book, and the only treatise which can be regarded as a really reliable manual of the plumber's art."—*Building News.*

Geometry for the Architect, Engineer, etc.

PRACTICAL GEOMETRY, for the Architect, Engineer and Mechanic. Giving Rules for the Delineation and Application of various Geometrical Lines, Figures and Curves. By E. W. TARN, M.A., Architect, Author of "The Science of Building," &c. Second Edition. With 172 Illustrations, demy 8vo, 9s. cloth.

"No book with the same objects in view has ever been published in which the clearness of the rules laid down and the illustrative diagrams have been so satisfactory."—*Scotsman.*

The Science of Geometry.

THE GEOMETRY OF COMPASSES; or, Problems Resolved by the mere Description of Circles, and the use of Coloured Diagrams and Symbols. By OLIVER BYRNE. Coloured Plates. Crown 8vo, 3s. 6d. cloth.

"The treatise is a good one, and remarkable—like all Mr. Byrne's contributions to the science of geometry—for the lucid character of its teaching."—*Building News.*

DECORATIVE ARTS, etc.

Woods and Marbles (Imitation of).

SCHOOL OF PAINTING FOR THE IMITATION OF WOODS AND MARBLES, as Taught and Practised by A. R. VAN DER BURG and P. VAN DER BURG, Directors of the Rotterdam Painting Institution. Royal folio, 18½ by 12½ in., Illustrated with 24 full-size Coloured Plates; also 12 plain Plates, comprising 154 Figures. Second and Cheaper Edition. Price £1 11s. 6d.

List of Plates.

1. Various Tools required for Wood Painting—2, 3. Walnut: Preliminary Stages of Graining and Finished Specimen—4. Tools used for Marble Painting and Method of Manipulation—5, 6. St. Remi Marble: Earlier Operations and Finished Specimen—7. Methods of Sketching different Grains, Knots, &c.—8, 9. Ash: Preliminary Stages and Finished Specimen—10. Methods of Sketching Marble Grains—11, 12. Breche Marble: Preliminary Stages of Working and Finished Specimen—13. Maple: Methods of Producing the different Grains—14, 15. Bird's-eye Maple: Preliminary Stages and Finished Specimen—16. Methods of Sketching the different Species of White Marble—17, 18. White Marble: Preliminary Stages of Process and Finished Specimen—19. Mahogany: Specimens of various Grains and Methods of Manipulation—20, 21. Mahogany: Earlier Stages and Finished Specimen—22, 23, 24. Sienna Marble: Varieties of Grain, Preliminary Stages and Finished Specimen—25, 26, 27. Juniper Wood: Methods of producing Grain, &c.: Preliminary Stages and Finished Specimen—28, 29, 30. Vert de Mer Marble: Varieties of Grain and Methods of Working Unfinished and Finished Specimens—31, 32, 33. Oak: Varieties of Grain, Tools Employed, and Methods of Manipulation, Preliminary Stages and Finished Specimen—34, 35, 36. Waulsort Marble: Varieties of Grain, Unfinished and Finished Specimens.

*** OPINIONS OF THE PRESS.

"Those who desire to attain skill in the art of painting woods and marbles will find advantage in consulting this book. . . . Some of the Working Men's Clubs should give their young men the opportunity to study it."—*Builder.*

"A comprehensive guide to the art. The explanations of the processes, the manipulation and management of the colours, and the beautifully executed plates will not be the least valuable to the student who aims at making his work a faithful transcript of nature."—*Building News.*

House Decoration.

ELEMENTARY DECORATION. A Guide to the Simpler Forms of Everyday Art, as applied to the Interior and Exterior Decoration of Dwelling Houses, &c. By JAMES W. FACEY, Jun. With 68 Cuts. 12mo, 2*s.* cloth limp.

PRACTICAL HOUSE DECORATION: A Guide to the Art of Ornamental Painting, the Arrangement of Colours in Apartments, and the principles of Decorative Design. With some Remarks upon the Nature and Properties of Pigments. By JAMES WILLIAM FACEY, Author of "Elementary Decoration," &c. With numerous Illustrations. 12mo, 2*s.* 6*d.* cloth limp.

N.B.—The above Two Works together in One Vol., strongly half-bound, 5*s.*

Colour.

A GRAMMAR OF COLOURING. Applied to Decorative Painting and the Arts. By GEORGE FIELD. New Edition, Revised, Enlarged, and adapted to the use of the Ornamental Painter and Designer. By ELLIS A. DAVIDSON. With New Coloured Diagrams and Engravings. 12mo, 3*s.* 6*d.* cloth boards.

"The book is a most useful *resume* of the properties of pigments."—*Builder.*

House Painting, Graining, etc.

HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING, A Practical Manual of. By ELLIS A. DAVIDSON. Sixth Edition. With Coloured Plates and Wood Engravings. 12mo, 6*s.* cloth boards.

"A mass of information, of use to the amateur and of value to the practical man."—*English Mechanic.*

"Simply invaluable to the youngster entering upon this particular calling, and highly serviceable to the man who is practising it."—*Furniture Gazette.*

Decorators, Receipts for.

THE DECORATOR'S ASSISTANT: A Modern Guide to Decorative Artists and Amateurs, Painters, Writers, Gilders, &c. Containing upwards of 600 Receipts, Rules and Instructions; with a variety of Information for General Work connected with every Class of Interior and Exterior Decorations, &c. Fourth Edition, Revised. 152 pp., crown 8vo, 1*s.* in wrapper.

"Full of receipts of value to decorators, painters, gilders, &c. The book contains the gist of larger treatises on colour and technical processes. It would be difficult to meet with a work so full of varied information on the painter's art."—*Building News.*

"We recommend the work to all who, whether for pleasure or profit, require a guide to decoration."—*Plumber and Decorator.*

Moyr Smith on Interior Decoration.

ORNAMENTAL INTERIORS, ANCIENT AND MODERN. By J. MOYR SMITH. Super-royal 8vo, with 32 full-page Plates and numerous smaller Illustrations, handsomely bound in cloth, gilt top, price 18*s.*

"The book is well illustrated and handsomely got up, and contains some true criticism and a good many good examples of decorative treatment."—*The Builder.*

"This is the most elaborate and beautiful work on the artistic decoration of interiors that we have seen. . . . The scrolls, panels and other designs from the author's own pen are very beautiful and chaste; but he takes care that the designs of other men shall figure even more than his own."—*Liverpool Albion.*

"To all who take an interest in elaborate domestic ornament this handsome volume will be welcome."—*Graphic.*

British and Foreign Marbles.

MARBLE DECORATION and the Terminology of British and Foreign Marbles. A Handbook for Students. By GEORGE H. BLAGROVE, Author of "Shoring and its Application," &c. With 28 Illustrations. Crown 8vo, 3*s.* 6*d.* cloth.

"This most useful and much wanted handbook should be in the hands of every architect and builder."—*Building World.*

"It is an excellent manual for students, and interesting to artistic readers generally."—*Saturday Review.*

"A carefully and usefully written treatise; the work is essentially practical."—*Scotsman.*

Marble Working, etc.

MARBLE AND MARBLE WORKERS: A Handbook for Architects, Artists, Masons and Students. By ARTHUR LEE, Author of "A Visit to Carrara," "The Working of Marble," &c. Small crown 8vo, 2*s.* cloth.

"A really valuable addition to the technical literature of architects and masons."—*Building News.*

DELAMOTTE'S WORKS ON ILLUMINATION AND ALPHABETS.

A PRIMER OF THE ART OF ILLUMINATION, for the Use of Beginners: with a Rudimentary Treatise on the Art, Practical Directions for its exercise, and Examples taken from Illuminated MSS., printed in Gold and Colours. By F. DELAMOTTE. New and Cheaper Edition. Small 4to, 6s. ornamental boards.

"The examples of ancient MSS. recommended to the student, which, with much good sense, the author chooses from collections accessible to all, are selected with judgment and knowledge, as well as taste."—*Athenæum.*

ORNAMENTAL ALPHABETS, Ancient and Mediæval, from the Eighth Century, with Numerals; including Gothic, Church-Text, large and small, German, Italian, Arabesque, Initials for Illumination, Monograms, Crosses, &c. &c., for the use of Architectural and Engineering Draughtsmen, Missal Painters, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, 2s. 6*d.* ornamental boards.

"For those who insert enamelled sentences round gilded chalices, who blazon shop legends over shop-doors, who letter church walls with pithy sentences from the Decalogue, this book will be useful."—*Athenæum.*

EXAMPLES OF MODERN ALPHABETS, Plain and Ornamental; including German, Old English, Saxon, Italic, Perspective, Greek, Hebrew, Court Hand, Engrossing, Tuscan, Riband, Gothic, Rustic, and Arabesque; with several Original Designs, and an Analysis of the Roman and Old English Alphabets, large and small, and Numerals, for the use of Draughtsmen, Surveyors, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, 2s. 6*d.* ornamental boards.

"There is comprised in it every possible shape into which the letters of the alphabet and numerals can be formed, and the talent which has been expended in the conception of the various plain and ornamental letters is wonderful."—*Standard.*

MEDIÆVAL ALPHABETS AND INITIALS FOR ILLUMINATORS. By F. G. DELAMOTTE. Containing 21 Plates and Illuminated Title, printed in Gold and Colours. With an Introduction by J. WILLIS BROOKS. Fourth and Cheaper Edition. Small 4to, 4*s.* ornamental boards.

"A volume in which the letters of the alphabet come forth glorified in gilding and all the colours of the prism interwoven and intertwined and intermingled."—*Sun.*

THE EMBROIDERER'S BOOK OF DESIGN. Containing Initials, Emblems, Cyphers, Monograms, Ornamental Borders, Ecclesiastical Devices, Mediæval and Modern Alphabets, and National Emblems. Collected by F. DELAMOTTE, and printed in Colours. Oblong royal 8vo, 1s. 6*d.* ornamental wrapper.

"The book will be of great assistance to ladies and young children who are endowed with the art of plying the needle in this most ornamental and useful pretty work."—*East Anglian Times.*

Wood Carving.

INSTRUCTIONS IN WOOD-CARVING, for Amateurs; with Hints on Design. By A LADY. With Ten Plates. New and Cheaper Edition. Crown 8vo, 2s. in emblematic wrapper.

"The handicraft of the wood-carver, so well as a book can impart it, may be learnt from 'A Lady's' publication."—*Athenæum.*

"The directions given are plain and easily understood."—*English Mechanic.*

Glass Painting.

GLASS STAINING AND THE ART OF PAINTING ON GLASS. From the German of Dr. GESSERT and EMANUEL OTTO FROMBERG. With an Appendix on THE ART OF ENAMELLING. 12mo, 2s. 6*d.* cloth limp.

Letter Painting.

THE ART OF LETTER PAINTING MADE EASY. By JAMES GREIG BADENOCH. With 12 full-page Engravings of Examples, 1s. 6*d.* cloth limp.

"The system is a simple one, but quite original, and well worth the careful attention of letter painters. It can be easily mastered and remembered."—*Building News.*

CARPENTRY, TIMBER, etc.

Tredgold's Carpentry, Revised & Enlarged by Tarn.

THE ELEMENTARY PRINCIPLES OF CARPENTRY. A Treatise on the Pressure and Equilibrium of Timber Framing, the Resistance of Timber, and the Construction of Floors, Arches, Bridges, Roofs, Uniting Iron and Stone with Timber, &c. To which is added an Essay on the Nature and Properties of Timber, &c., with Descriptions of the kinds of Wood used in Building; also numerous Tables of the Scantlings of Timber for different purposes, the Specific Gravities of Materials, &c. By THOMAS TREDGOLD, C.E. With an Appendix of Specimens of Various Roofs of Iron and Stone, Illustrated. Seventh Edition, thoroughly revised and considerably enlarged by E. WYNDHAM TARN, M.A., Author of "The Science of Building," &c. With 61 Plates, Portrait of the Author, and several Woodcuts. In one large vol., 4to, price £1 5s. cloth.

"Ought to be in every architect's and every builder's library."—*Builder.*

"A work whose monumental excellence must commend it wherever skilful carpentry is concerned. The author's principles are rather confirmed than impaired by time. The additional plates are of great intrinsic value."—*Building News.*

Woodworking Machinery.

WOODWORKING MACHINERY: Its Rise, Progress, and Construction. With Hints on the Management of Saw Mills and the Economical Conversion of Timber. Illustrated with Examples of Recent Designs by leading English, French, and American Engineers. By M. POWIS BALE A.M.Inst.C.E., M.I.M.E. Large crown 8vo, 12s. 6d. cloth.

"Mr. Bale is evidently an expert on the subject and he has collected so much information that his book is all-sufficient for builders and others engaged in the conversion of timber."—*Architect.*

"The most comprehensive compendium of wood-working machinery we have seen. The author is a thorough master of his subject."—*Building News.*

"The appearance of this book at the present time will, we should think, give a considerable impetus to the onward march of the machinist engaged in the designing and manufacture of wood-working machines. It should be in the office of every wood-working factory."—*English Mechanic.*

Saw Mills.

SAW MILLS: Their Arrangement and Management, and the Economical Conversion of Timber. (A Companion Volume to "Woodworking Machinery.") By M. POWIS BALE. With numerous Illustrations. Crown 8vo, 10s. 6d. cloth.

"The *administration* of a large sawing establishment is discussed, and the subject examined from a financial standpoint. We could not desire a more complete or practical treatise."—*Builder.*

"We highly recommend Mr. Bale's work to the attention and perusal of all those who are engaged in the art of wood conversion, or who are about building or remodelling saw-mills on improved principles."—*Building News.*

Carpentering.

THE CARPENTER'S NEW GUIDE; or, Book of Lines for Carpenters; comprising all the Elementary Principles essential for acquiring a knowledge of Carpentry. Founded on the late PETER NICHOLSON'S Standard Work. A New Edition, Revised by ARTHUR ASHPITEL, F.S.A. Together with Practical Rules on Drawing, by GEORGE PYNE. With 74 Plates, 4to, £1 1s. cloth.

Handrailing and Stairbuilding.

A PRACTICAL TREATISE ON HANDRAILING: Showing New and Simple Methods for Finding the Pitch of the Plank, Drawing the Moulds, Bevelling, Jointing-up, and Squaring the Wreath. By GEORGE COLLINGS. Second Edition, Revised and Enlarged, to which is added A TREATISE ON STAIRBUILDING. With Plates and Diagrams. 12mo, 2s. 6d. cloth limp.

"Will be found of practical utility in the execution of this difficult branch of joinery."—*Builder.*

"Almost every difficult phase of this somewhat intricate branch of joinery is elucidated by the aid of plates and explanatory letterpress."—*Furniture Gazette.*

Circular Work.

CIRCULAR WORK IN CARPENTRY AND JOINERY: A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS, Author of "A Practical Treatise on Handrailing." Illustrated with numerous Diagrams. Second Edition. 12mo, 2s. 6d. cloth limp.

"An excellent example of what a book of this kind should be. Cheap in price, clear in definition and practical in the examples selected."—*Builder.*

Timber Merchant's Companion.

THE TIMBER MERCHANT'S AND BUILDER'S COMPANION. Containing New and Copious Tables of the Reduced Weight and Measurement of Deals and Battens, of all sizes, from One to a Thousand Pieces, and the relative Price that each size bears per Lineal Foot to any given Price per Petersburg Standard Hundred; the Price per Cube Foot of Square Timber to any given Price per Load of 50 Feet; the proportionate Value of Deals and Battens by the Standard, to Square Timber by the Load of 50 Feet; the readiest mode of ascertaining the Price of Scantling per Lineal Foot of any size, to any given Figure per Cube Foot, &c. &c. By WILLIAM DOWSING. Fourth Edition, Revised and Corrected. Cr. 8vo, 3s. cl.

"We are glad to see a fourth edition of these admirable tables, which for correctness and simplicity of arrangement leave nothing to be desired."—*Timber Trades Journal.*

"An exceedingly well-arranged, clear, and concise manual of tables for the use of all who buy or sell timber."—*Journal of Forestry.*

Practical Timber Merchant.

THE PRACTICAL TIMBER MERCHANT. Being a Guide for the use of Building Contractors, Surveyors, Builders, &c., comprising useful Tables for all purposes connected with the Timber Trade, Marks of Wood, Essay on the Strength of Timber, Remarks on the Growth of Timber, &c. By W. RICHARDSON. Fcap. 8vo, 3s. 6d. cloth.

"This handy manual contains much valuable information for the use of timber merchants, builders, foresters, and all others connected with the growth, sale, and manufacture of timber."—*Journal of Forestry.*

Timber Freight Book.

THE TIMBER MERCHANT'S, SAW MILLER'S, AND IMPORTER'S FREIGHT BOOK AND ASSISTANT. Comprising Rules, Tables, and Memoranda relating to the Timber Trade. By WILLIAM RICHARDSON, Timber Broker; together with a Chapter on "SPEEDS OF SAW MILL MACHINERY," by M. POWIS BALE, M.I.M.E., &c. 12mo, 3s. 6d. cl. boards.

"A very useful manual of rules, tables, and memoranda relating to the timber trade. We recommend it as a compendium of calculation to all timber measurers and merchants, and as supplying a real want in the trade."—*Building News.*

Packing-Case Makers, Tables for.

PACKING-CASE TABLES; showing the number of Superficial Feet in Boxes or Packing-Cases, from six inches square and upwards. By W. RICHARDSON, Timber Broker. Third Edition. Oblong 4to, 3s. 6d. cl.

"Invaluable labour-saving tables."—*Ironmonger.*

"Will save much labour and calculation."—*Grocer.*

Superficial Measurement.

THE TRADESMAN'S GUIDE TO SUPERFICIAL MEASUREMENT. Tables calculated from 1 to 200 inches in length, by 1 to 108 inches in breadth. For the use of Architects, Surveyors, Engineers, Timber Merchants, Builders, &c. By JAMES HAWKINGS. Third Edition. Fcap., 3s. 6d. cloth.

"A useful collection of tables to facilitate rapid calculation of surfaces. The exact area of any surface of which the limits have been ascertained can be instantly determined. The book will be found of the greatest utility to all engaged in building operations."—*Scotsman.*

"These tables will be found of great assistance to all who require to make calculations in superficial measurement."—*English Mechanic.*

Forestry.

THE ELEMENTS OF FORESTRY. Designed to afford Information concerning the Planting and Care of Forest Trees for Ornament or Profit, with Suggestions upon the Creation and Care of Woodlands. By F. B. HOUGH. Large crown 8vo, 10s. cloth.

Timber Importer's Guide.

THE TIMBER IMPORTER'S, TIMBER MERCHANT'S AND BUILDER'S STANDARD GUIDE. By RICHARD E. GRANDY. Comprising an Analysis of Deal Standards, Home and Foreign, with Comparative Values and Tabular Arrangements for fixing Nett Landed Cost on Baltic and North American Deals, including all intermediate Expenses, Freight, Insurance, &c. &c. Together with copious Information for the Retailer and Builder. Third Edition, Revised. 12mo, 2s. cloth limp.

"Everything it pretends to be: built up gradually, it leads one from a forest to a treenail, and throws in, as a makeweight, a host of material concerning bricks, columns, cisterns, &c."—*English Mechanic.*

MARINE ENGINEERING, NAVIGATION, etc.

Chain Cables.

CHAIN CABLES AND CHAINS. Comprising Sizes and Curves of Links, Studs, &c., Iron for Cables and Chains, Chain Cable and Chain Making, Forming and Welding Links, Strength of Cables and Chains, Certificates for Cables, Marking Cables, Prices of Chain Cables and Chains, Historical Notes, Acts of Parliament, Statutory Tests, Charges for Testing, List of Manufacturers of Cables, &c. &c. By THOMAS W. TRAILL, F.E.R.N., M. Inst. C.E., Engineer Surveyor in Chief, Board of Trade, Inspector of Chain Cable and Anchor Proving Establishments, and General Superintendent, Lloyd's Committee on Proving Establishments. With numerous Tables, Illustrations and Lithographic Drawings. Folio, £2 2s. cloth, bevelled boards.

"It contains a vast amount of valuable information. Nothing seems to be wanting to make it a complete and standard work of reference on the subject."—*Nautical Magazine.*

Marine Engineering.

MARINE ENGINES AND STEAM VESSELS (A Treatise on). By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with considerable Additions by the Author and by GEORGE CARLISLE, C.E., Senior Surveyor to the Board of Trade at Liverpool. 12mo, 5s. cloth boards.

"Well adapted to give the young steamship engineer or marine engine and boiler maker a general introduction into his practical work."—*Mechanical World.*

"We feel sure that this thoroughly revised edition will continue to be as popular in the future as it has been in the past, as, for its size, it contains more useful information than any similar treatise."—*Industries.*

The information given is both sound and sensible, and well qualified to direct young seagoing hands on the straight road to the extra chief's certificate. Most useful to surveyors, inspectors, draughtsmen, and all young engineers who take an interest in their profession."—*Glasgow Herald.*

"An indispensable manual for the student of marine engineering."—*Liverpool Mercury.*

Pocket-Book for Naval Architects and Shipbuilders.

THE NAVAL ARCHITECT'S AND SHIPBUILDER'S POCKET-BOOK of Formulæ, Rules, and Tables, and MARINE ENGINEER'S AND SURVEYOR'S Handy Book of Reference. By CLEMENT MACKROW, Member of the Institution of Naval Architects, Naval Draughtsman. Fourth Edition, Revised. With numerous Diagrams, &c. Fcap., 12s. 6d. strongly bound in leather.

"Will be found to contain the most useful tables and formulæ required by shipbuilders, carefully collected from the best authorities, and put together in a popular and simple form."—*Engineer.*

"The professional shipbuilder has now, in a convenient and accessible form, reliable data for solving many of the numerous problems that present themselves in the course of his work."—*Iron.*

"There is scarcely a subject on which a naval architect or shipbuilder can require to refresh his memory which will not be found within the covers of Mr. Mackrow's book."—*English Mechanic.*

Pocket-Book for Marine Engineers.

A POCKET-BOOK OF USEFUL TABLES AND FORMULÆ FOR MARINE ENGINEERS. By FRANK PROCTOR, A.I.N.A. Third Edition. Royal 32mo, leather, gilt edges, with strap, 4s.

"We recommend it to our readers as going far to supply a long-felt want."—*Naval Science.*

"A most useful companion to all marine engineers."—*United Service Gazette.*

Introduction to Marine Engineering.

ELEMENTARY ENGINEERING: A Manual for Young Marine Engineers and Apprentices. In the Form of Questions and Answers on Metals, Alloys, Strength of Materials, Construction and Management of Marine Engines and Boilers, Geometry, &c. &c. With an Appendix of Useful Tables. By JOHN SHERREN BREWER, Government Marine Surveyor, Hongkong. Small crown 8vo, 2s. cloth.

"Contains much valuable information for the class for whom it is intended, especially in the chapters on the management of boilers and engines."—*Nautical Magazine.*

"A useful introduction to the more elaborate text books."—*Scotsman.*

"To a student who has the requisite desire and resolve to attain a thorough knowledge, Mr. Brewer offers decidedly useful help."—*Athenæum.*

Navigation.

PRACTICAL NAVIGATION. Consisting of THE SAILOR'S SEA-BOOK, by JAMES GREENWOOD and W. H. ROSSER; together with the requisite Mathematical and Nautical Tables for the Working of the Problems, by HENRY LAW, C.E., and Professor J. R. YOUNG. Illustrated. 12mo, 7s. strongly half-bound.

MINING AND METALLURGY.

Metalliferous Mining in the United Kingdom.

BRITISH MINING: A Treatise on the History, Discovery, Practical Development, and Future Prospects of Metalliferous Mines in the United Kingdom. By ROBERT HUNT, F.R.S., Keeper of Mining Records; Editor of "Ure's Dictionary of Arts, Manufactures, and Mines," &c. Upwards of 950 pp., with 230 Illustrations. Second Edition, Revised. Super-royal 8vo, £2 2*s*. cloth.

"One of the most valuable works of reference of modern times. Mr. Hunt, as keeper of mining records of the United Kingdom, has had opportunities for such a task not enjoyed by anyone else, and has evidently made the most of them. . . . The language and style adopted are good, and the treatment of the various subjects laborious, conscientious, and scientific."—*Engineering.*

"The book is, in fact, a treasure-house of statistical information on mining subjects, and we know of no other work embodying so great a mass of matter of this kind. Were this the only merit of Mr. Hunt's volume, it would be sufficient to render it indispensable in this library of everyone interested in the development of the mining and metallurgical industries of this country."—*Athenæum.*

"A mass of information not elsewhere available, and of the greatest value to those who may be interested in our great mineral industries."—*Engineer.*

"A sound, business-like collection of interesting facts. . . . The amount of information Mr. Hunt has brought together is enormous. . . . The volume appears likely to convey more instruction upon the subject than any work hitherto published."—*Mining Journal.*

Colliery Management.

THE COLLIERY MANAGER'S HANDBOOK: A Comprehensive Treatise on the Laying-out and Working of Collieries, Designed as a Book of Reference for Colliery Managers, and for the Use of Coal-Mining Students preparing for First-class Certificates. By CALEB PAMELY, Mining Engineer and Surveyor; Member of the North of England Institute of Mining and Mechanical Engineers; and Member of the South Wales Institute of Mining Engineers. With nearly 500 Plans, Diagrams, and other Illustrations. Medium 8vo, about 600 pages. Price £1 5*s*. strongly bound. [*Just published.*

Coal and Iron.

THE COAL AND IRON INDUSTRIES OF THE UNITED KINGDOM. Comprising a Description of the Coal Fields, and of the Principal Seams of Coal, with Returns of their Produce and its Distribution, and Analyses of Special Varieties. Also an Account of the occurrence of Iron Ores in Veins or Seams; Analyses of each Variety; and a History of the Rise and Progress of Pig Iron Manufacture. By RICHARD MEADE, Assistant Keeper of Mining Records. With Maps. 8vo, £1 8*s*. cloth.

"The book is one which must find a place on the shelves of all interested in coal and iron production, and in the iron, steel, and other metallurgical industries."—*Engineer.*

"Of this book we may unreservedly say that it is the best of its class which we have ever met. . . A book of reference which no one engaged in the iron or coal trades should omit from his library."—*Iron and Coal Trades Review.*

Prospecting for Gold and other Metals.

THE PROSPECTOR'S HANDBOOK: A Guide for the Prospector and Traveller in Search of Metal-Bearing or other Valuable Minerals. By J. W. ANDERSON, M.A. (Camb.), F.R.G.S., Author of "Fiji and New Caledonia." Fifth Edition, thoroughly Revised and Enlarged. Small crown 8vo, 3*s*. 6*d*. cloth.

"Will supply a much felt want, especially among Colonists, in whose way are so often thrown many mineralogical specimens the value of which it is difficult to determine."—*Engineer.*

"How to find commercial minerals, and how to identify them when they are found, are the leading points to which attention is directed. The author has managed to pack as much practical detail into his pages as would supply material for a book three times its size."—*Mining Journal.*

Mining Notes and Formulæ.

NOTES AND FORMULÆ FOR MINING STUDENTS. By JOHN HERMAN MERIVALE, M.A., Certificated Colliery Manager, Professor of Mining in the Durham College of Science, Newcastle-upon-Tyne. Third Edition, Revised and Enlarged. Small crown 8vo, 2*s*. 6*d*. cloth.

"Invaluable to anyone who is working up for an examination on mining subjects."—*Coal and Iron Trades Review.*

"The author has done his work in an exceedingly creditable manner, and has produced a book that will be of service to students, and those who are practically engaged in mining operations."—*Engineer.*

"A vast amount of technical matter of the utmost value to mining engineers, and of considerable interest to students."—*Schoolmaster.*

Explosives.

A HANDBOOK ON MODERN EXPLOSIVES. Being a Practical Treatise on the Manufacture and Application of Dynamite, Gun-Cotton, Nitro-Glycerine and other Explosive Compounds. Including the Manufacture of Collodion-Cotton. By M. EISSLER, Mining Engineer and Metallurgical Chemist, Author of "The Metallurgy of Gold," &c. With about 100 Illustrations. Crown 8vo, 10*s.* 6*d.* cloth.

"Useful not only to the miner, but also to officers of both services to whom blasting and the use of explosives generally may at any time become a necessary auxiliary."—*Nature.*

"A veritable mine of information on the subject of explosives employed for military, mining and blasting purposes."—*Army and Navy Gazette.*

"The book is clearly written. Taken as a whole, we consider it an excellent little book and one that should be found of great service to miners and others who are engaged in work requiring the use of explosives."—*Athenæum.*

Gold, Metallurgy of.

THE METALLURGY OF GOLD: A Practical Treatise on the Metallurgical Treatment of Gold-bearing Ores. Including the Processes of Concentration and Chlorination, and the Assaying, Melting and Refining of Gold. By M. EISSLER, Mining Engineer and Metallurgical Chemist, formerly Assistant Assayer of the U. S. Mint, San Francisco. Third Edition, Revised and greatly Enlarged. With 187 Illustrations. Crown 8vo, 12*s.* 6*d.* cloth.

"This book thoroughly deserves its title of a 'Practical Treatise.' The whole process of gold milling, from the breaking of the quartz to the assay of the bullion, is described in clear and orderly narrative and with much, but not too much, fulness of detail."—*Saturday Review.*

"The work is a storehouse of information and valuable data, and we strongly recommend it to all professional men engaged in the gold-mining industry."—*Mining Journal*

Silver, Metallurgy of.

THE METALLURGY OF SILVER: A Practical Treatise on the Amalgamation, Roasting and Lixiviation of Silver Ores, Including the Assaying, Melting and Refining of Silver Bullion. By M. EISSLER, Author of "The Metallurgy of Gold" Second Edition, Enlarged. With 150 Illustrations. Crown 8vo, 10*s.* 6*d.* cloth. [*Just published.*

"A practical treatise, and a technical work which we are convinced will supply a long-felt want amongst practical men, and at the same time be of value to students and others indirectly connected with the industries."—*Mining Journal.*

"From first to last the book is thoroughly sound and reliable."—*Colliery Guardian.*

"For chemists, practical miners, assayers and investors alike, we do not know of any work on the subject so handy and yet so comprehensive."—*Glasgow Herald.*

Silver-Lead, Metallurgy of.

THE METALLURGY OF ARGENTIFEROUS LEAD: A Practical Treatise on the Smelting of Silver-Lead Ores and the Refining of Lead Bullion. Including Reports on various Smelting Establishments and Descriptions of Modern Furnaces and Plants in Europe and America. By M. EISSLER, M.E., Author of "The Metallurgy of Gold," &c. Crown 8vo. 400 pp., with numerous Illustrations, 12*s.* 6*d.* cloth. [*Just published.*

Metalliferous Minerals and Mining.

TREATISE ON METALLIFEROUS MINERALS AND MINING. By D. C. DAVIES, F.G.S., Mining Engineer, &c., Author of "A Treatise on Slate and Slate Quarrying." Illustrated with numerous Wood Engravings. Fourth Edition, carefully Revised. Crown 8vo, 12*s.* 6*d.* cloth.

"Neither the practical miner nor the general reader interested in mines can have a better book for his companion and his guide."—*Mining Journal.*

"We are doing our readers a service in calling their attention to this valuable work."—[*Mining World.*

"As a history of the present state of mining throughout the world this book has a real value, and it supplies an actual want."—*Athenæum.*

Earthy Minerals and Mining.

A TREATISE ON EARTHY & OTHER MINERALS AND MINING. By D. C. DAVIES, F.G.S.. Uniform with, and forming a Companion Volume to, the same Author's "Metalliferous Minerals and Mining." With 76 Wood Engravings. Second Edition. Crown 8vo, 12*s.* 6*d.* cloth.

"We do not remember to have met with any English work on mining matters that contains the same amount of information packed in equally convenient form."—*Academy.*

"We should be inclined to rank it as among the very best of the handy technical and trades manuals which have recently appeared."—*British Quarterly Review.*

Mineral Surveying and Valuing.

THE MINERAL SURVEYOR AND VALUER'S COMPLETE GUIDE, comprising a Treatise on Improved Mining Surveying and the Valuation of Mining Properties, with New Traverse Tables. By WM. LINTERN, Mining and Civil Engineer. Third Edition, with an Appendix on "Magnetic and Angular Surveying," with Records of the Peculiarities of Needle Disturbances. With Four Plates of Diagrams, Plans, &c. 12mo, 4s. cloth.

"Mr. Lintern's book forms a valuable and thoroughly trustworthy guide."—*Iron and Coal Trades Review.*

"This new edition must be of the highest value to colliery surveyors, proprietors and managers."—*Colliery Guardian.*

Asbestos and its Uses.

ASBESTOS: Its Properties, Occurrence and Uses. With some Account of the Mines of Italy and Canada. By ROBERT H. JONES. With Eight Collotype Plates and other Illustrations. Crown 8vo, 12s. 6d. cloth.

"An interesting and invaluable work."—*Colliery Guardian.*

"We counsel our readers to get this exceedingly interesting work for themselves; they will find in it much that is suggestive, and a great deal that is of immediate and practical usefulness."—*Builder.*

"A valuable addition to the architect's and engineer's library."—*Building News.*

Underground Pumping Machinery.

MINE DRAINAGE. Being a Complete and Practical Treatise on Direct-Acting Underground Steam Pumping Machinery, with a Description of a large number of the best known Engines, their General Utility and the Special Sphere of their Action, the Mode of their Application, and their merits compared with other forms of Pumping Machinery. By STEPHEN MICHELL. 8vo, 15s. cloth.

"Will be highly esteemed by colliery owners and lessees, mining engineers, and students generally who require to be acquainted with the best means of securing the drainage of mines. It is a most valuable work, and stands almost alone in the literature of steam pumping machinery."—*Colliery Guardian.*

"Much valuable information is given, so that the book is thoroughly worthy of an extensive circulation amongst practical men and purchasers of machinery."—*Mining Journal.*

Mining Tools.

A MANUAL OF MINING TOOLS. For the Use of Mine Managers, Agents, Students, &c. By WILLIAM MORGANS, Lecturer on Practical Mining at the Bristol School of Mines. 12mo, 2s. 6d. cloth limp.

ATLAS OF ENGRAVINGS to Illustrate the above, containing 235 Illustrations of Mining Tools, drawn to scale. 4to, 4s. 6d. cloth.

"Students in the science of mining, and overmen, captains, managers, and viewers may gain practical knowledge and useful hints by the study of Mr. Morgans' manual."—*Colliery Guardian.*

"A valuable work, which will tend materially to improve our mining literature."—*Mining Journal.*

Coal Mining.

COAL AND COAL MINING: A Rudimentary Treatise on. By the late Sir WARINGTON W. SMYTH, M.A., F.R.S., &c., Chief Inspector of the Mines of the Crown. Seventh Edition, Revised and Enlarged. With numerous Illustrations. 12mo, 4s. cloth boards.

"As an outline is given of every known coal-field in this and other countries, as well as of the principal methods of working, the book will doubtless interest a very large number of readers."—*Mining Journal.*

Subterraneous Surveying.

SUBTERRANEOUS SURVEYING, Elementary and Practical Treatise on, with and without the Magnetic Needle. By THOMAS FENWICK, Surveyor of Mines, and THOMAS BAKER, C.E. Illust. 12mo, 3s. cloth boards.

Granite Quarrying.

GRANITES AND OUR GRANITE INDUSTRIES. By GEORGE F. HARRIS, F.G.S., Membre de la Société Belge de Géologie, Lecturer on Economic Geology at the Birkbeck Institution, &c. With Illustrations. Crown 8vo, 2s. 6d. cloth.

"A clearly and well-written manual for persons engaged or interested in the granite industry."—*Scotsman.*

"An interesting work, which will be deservedly esteemed."—*Colliery Guardian.*

"An exceedingly interesting and valuable monograph on a subject which has hitherto received unaccountably little attention in the shape of systematic literary treatment."—*Scottish Leader.*

ELECTRICITY ELECTRICAL ENGINEERING, etc.

Electrical Engineering.

THE ELECTRICAL ENGINEER'S POCKET-BOOK OF MODERN RULES, FORMULÆ, TABLES AND DATA. By H. R. KEMPE, M.Inst.E.E., A.M.Inst C.E., Technical Officer Postal Telegraphs, Author of "A Handbook of Electrical Testing," &c. With numerous Illustrations, royal 32mo, oblong, 5*s.* leather. [*Just published.*

"There is very little in the shape of formulæ or data which the electrician is likely to want in a hurry which cannot be found in its pages."—*Practical Engineer.*

"A very useful book of reference for daily use in practical electrical engineering and its various applications to the industries of the present day."—*Iron.*

"It is the best book of its kind."—*Electrical Engineer.*

"The Electrical Engineer's Pocket-Book is a good one."—*Electrician.*

"Strongly recommended to those engaged in the various electrical industries."—*Electrical Review.*

Electric Lighting.

ELECTRIC LIGHT FITTING: A Handbook for Working Electrical Engineers, embodying Practical Notes on Installation Management. By JOHN W. URQUHART, Electrician, Author of "Electric Light," &c. With numerous Illustrations, crown 8vo, 5*s.* cloth. [*Just published.*

"This volume deals with what may be termed the mechanics of electric lighting, and is addressed to men who are already engaged in the work or are training for it. The work traverses a great deal of ground, and may be read as a sequel to the same author's useful work on 'Electric Light.'"—*Electrician.*

"This is an attempt to state in the simplest language the precautions which should be adopted in installing the electric light, and to give information, for the guidance of those who have to run the plant when installed. The book is well worth the perusal of the workmen for whom it is written."—*Electrical Review.*

"Eminently practical and useful. . . . Ought to be in the hands of everyone in charge of an electric light plant."—*Electrical Engineer.*

"A really capital book, which we have no hesitation in recommending to the notice of working electricians and electrical engineers."—*Mechanical World.*

Electric Light.

ELECTRIC LIGHT: Its Production and Use. Embodying Plain Directions for the Treatment of Dynamo-Electric Machines, Batteries, Accumulators, and Electric Lamps. By J. W. URQUHART, C.E., Author of "Electric Light Fitting," &c. Fourth Edition, Revised, with Large Additions and 145 Illustrations. Crown 8vo, 7*s.* 6*d.* cloth. [*Just published.*

"The book is by far the best that we have yet met with on the subject."—*Athenæum.*

"It is the only work at present available which gives, in language intelligible for the most part to the ordinary reader, a general but concise history of the means which have been adopted up to the present time in producing the electric light."—*Metropolitan.*

"The book contains a general account of the means adopted in producing the electric light, not only as obtained from voltaic or galvanic batteries, but treats at length of the dynamo-electric machine in several of its forms."—*Colliery Guardian.*

Construction of Dynamos.

DYNAMO CONSTRUCTION: A Practical Handbook for the Use of Engineer Constructors and Electricians in Charge. With Examples of leading English, American and Continental Dynamos and Motors. By J. W. URQUHART, Author of "Electric Light," &c. Crown 8vo, 7*s.* 6*d.* cloth. [*Just published.*

"The author has produced a book for which a demand has long existed. The subject is treated in a thoroughly practical manner."—*Mechanical World.*

Dynamic Electricity and Magnetism.

THE ELEMENTS OF DYNAMIC ELECTRICITY AND MAGNETISM By PHILIP ATKINSON, A.M., Ph.D. Crown 8vo. 400 pp. With 120 Illustrations. 10*s.* 6*d.* cloth. [*Just published.*

Text Book of Electricity.

THE STUDENT'S TEXT-BOOK OF ELECTRICITY. By HENRY M. NOAD, Ph.D., F.R.S., F.C.S. New Edition, carefully Revised. With an Introduction and Additional Chapters, by W. H. PREECE, M.I.C.E., Vice-President of the Society of Telegraph Engineers, &c. With 470 Illustrations. Crown 8vo, 12*s.* 6*d.* cloth.

"We can recommend Dr. Noad's book for clear style, great range of subject, a good index and a plethora of woodcuts. Such collections as the present are indispensable."—*Athenæum.*

"An admirable text book for every student — beginner or advanced — of electricity."—*Engineering.*

Electric Lighting.

THE ELEMENTARY PRINCIPLES OF ELECTRIC LIGHTING. By ALAN A. CAMPBELL SWINTON, Associate I.E.E. Second Edition, Enlarged and Revised. With 16 Illustrations. Crown 8vo, 1s. 6d. cloth.

"Anyone who desires a short and thoroughly clear exposition of the elementary principles of electric-lighting cannot do better than read this little work."—*Bradford Observer.*

Electricity.

A MANUAL OF ELECTRICITY: Including Galvanism, Magnetism, Dia-Magnetism, Electro-Dynamics, Magno-Electricity, and the Electric Telegraph. By HENRY M. NOAD, Ph.D., F.R.S., F.C.S. Fourth Edition. With 500 Woodcuts. 8vo, £1 4s. cloth.

"It is worthy of a place in the library of every public institution."—*Mining Journal.*

Dynamo Construction.

HOW TO MAKE A DYNAMO: A Practical Treatise for Amateurs. Containing numerous Illustrations and Detailed Instructions for Constructing a Small Dynamo, to Produce the Electric Light. By ALFRED CROFTS. Third Edition, Revised and Enlarged. Crown 8vo, 2s. cloth.

"The instructions given in this unpretentious little book are sufficiently clear and explicit to enable any amateur mechanic possessed of average skill and the usual tools to be found in an amateur's workshop, to build a practical dynamo machine."—*Electrician.*

NATURAL SCIENCE, etc.

Pneumatics and Acoustics.

PNEUMATICS: including Acoustics and the Phenomena of Wind Currents, for the Use of Beginners. By CHARLES TOMLINSON, F.R.S. F.C.S., &c. Fourth Edition, Enlarged. 12mo, 1s. 6d. cloth.

"Beginners in the study of this important application of science could not have a better manual." —*Scotsman.* "A valuable and suitable text-book for students of Acoustics and the Phenomena of Wind Currents."—*Schoolmaster.*

Conchology.

A MANUAL OF THE MOLLUSCA: Being a Treatise on Recent and Fossil Shells. By S. P. WOODWARD, A.L.S., F.G.S., late Assistant Palæontologist in the British Museum. With an Appendix on *Recent and Fossil Conchological Discoveries,* by RALPH TATE, A.L.S., F.G.S. Illustrated by A. N. WATERHOUSE and JOSEPH WILSON LOWRY. With 23 Plates and upwards of 300 Woodcuts. Reprint of Fourth Ed., 1880. Cr. 8vo, 7s. 6d. cl.

"A most valuable storehouse of conchological and geological information."—*Science Gossip.*

Geology.

RUDIMENTARY TREATISE ON GEOLOGY, PHYSICAL AND HISTORICAL. Consisting of "Physical Geology," which sets forth the leading Principles of the Science; and "Historical Geology," which treats of the Mineral and Organic Conditions of the Earth at each successive epoch, especial reference being made to the British Series of Rocks. By RALPH TATE, A.L.S., F.G.S., &c. With 250 Illustrations. 12mo, 5s. cloth.

"The fulness of the matter has elevated the book into a manual. Its information is exhaustive and well arranged."—*School Board Chronicle.*

Geology and Genesis.

THE TWIN RECORDS OF CREATION; or, Geology and Genesis: their Perfect Harmony and Wonderful Concord. By GEORGE W. VICTOR LE VAUX. Numerous Illustrations. Fcap. 8vo, 5s. cloth.

"A valuable contribution to the evidences of Revelation, and disposes very conclusively of the arguments of those who would set God's Works against God's Word."—*The Rock.*

The Constellations.

STAR GROUPS: A Student's Guide to the Constellations. By J. ELLARD GORE, F.R.A.S., M.R.I.A., &c., Author of "The Scenery of the Heavens." With 30 Maps. Small 4to, 5s. cloth, silvered. [*Just published.*

Astronomy.

ASTRONOMY. By the late Rev. ROBERT MAIN, M.A., F.R.S., formerly Radcliffe Observer at Oxford. Third Edition, Revised and Corrected to the present time, by W. T. LYNN, B.A., F.R.A.S. 12mo, 2s. cloth.

"A sound and simple treatise, very carefully edited, and a capital book for beginners."—*Knowledge.*

"Accurately brought down to the requirements of the present time by Mr. Lynn."—*Educational Times.*

DR. LARDNER'S COURSE OF NATURAL PHILOSOPHY.

THE HANDBOOK OF MECHANICS. Enlarged and almost re-written by BENJAMIN LOEWY, F.R.A.S. With 378 Illustrations. Post 8vo, 6*s.* cloth.

"The perspicuity of the original has been retained, and chapters which had become obsolete have been replaced by others of more modern character. The explanations throughout are studiously popular, and care has been taken to show the application of the various branches of physics to the industrial arts, and to the practical business of life."—*Mining Journal.*

"Mr. Loewy has carefully revised the book, and brought it up to modern requirements."—*Nature.*

"Natural philosophy has had few exponents more able or better skilled in the art of popularising the subject than Dr. Lardner; and Mr. Loewy is doing good service in fitting this treatise, and the others of the series, for use at the present time."—*Scotsman.*

THE HANDBOOK OF HYDROSTATICS AND PNEUMATICS. New Edition, Revised and Enlarged, by BENJAMIN LOEWY, F.R.A.S. With 236 Illustrations. Post 8vo, 5*s.* cloth.

"For those 'who desire to attain an accurate knowledge of physical science without the profound methods of mathematical investigation,' this work is not merely intended, but well adapted."—*Chemical News.*

"The volume before us has been carefully edited, augmented to nearly twice the bulk of the former edition, and all the most recent matter has been added. . . . It is a valuable text-book."—*Nature.*

"Candidates for pass examinations will find it, we think, specially suited to their requirements." *English Mechanic.*

THE HANDBOOK OF HEAT. Edited and almost entirely re-written by BENJAMIN LOEWY, F.R.A.S., &c. 117 Illustrations. Post 8vo, 6*s.* cloth.

"The style is always clear and precise, and conveys instruction without leaving any cloudiness or lurking doubts behind."—*Engineering.*

"A most exhaustive book on the subject on which it treats, and is so arranged that it can be understood by all who desire to attain an accurate knowledge of physical science. . . . Mr. Loewy has included all the latest discoveries in the varied laws and effects of heat."—*Standard.*

"A complete and handy text-book for the use of students and general readers."—*English Mechanic.*

THE HANDBOOK OF OPTICS. By DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. New Edition. Edited by T. OLVER HARDING, B.A. Lond., of University College, London. With 298 Illustrations. Small 8vo, 448 pages, 5*s.* cloth.

"Written by one of the ablest English scientific writers, beautifully and elaborately illustrated." *Mechanic's Magazine.*

THE HANDBOOK OF ELECTRICITY, MAGNETISM, AND ACOUSTICS. By Dr. LARDNER. Ninth Thousand. Edit. by GEORGE CAREY FOSTER, B.A., F.C.S. With 400 Illustrations. Small 8vo, 5*s.* cloth.

"The book could not have been entrusted to anyone better calculated to preserve the terse and lucid style of Lardner, while correcting his errors and bringing up his work to the present state of scientific knowledge."—*Popular Science Review.*

THE HANDBOOK OF ASTRONOMY. Forming a Companion to the "Handbook of Natural Philosophy." By DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. Fourth Edition. Revised and Edited by EDWIN DUNKIN, F.R.A.S., Royal Observatory, Greenwich. With 38 Plates and upwards of 100 Woodcuts. In One Vol., small 8vo, 550 pages, 9*s.* 6*d.* cloth.

"Probably no other book contains the same amount of information in so compendious and well-arranged a form—certainly none at the price at which this is offered to the public."—*Athenæum.*

"We can do no other than pronounce this work a most valuable manual of astronomy, and we strongly recommend it to all who wish to acquire a general—but at the same time correct—acquaintance with this sublime science."—*Quarterly Journal of Science.*

"One of the most deservedly popular books on the subject . . . We would recommend not only the student of the elementary principles of the science, but he who aims at mastering the higher and mathematical branches of astronomy, not to be without this work beside him."—*Practical Magazine.*

Dr. Lardner's Electric Telegraph.

THE ELECTRIC TELEGRAPH. By Dr. LARDNER. Revised and Re-written by E. B. BRIGHT, F.R.A.S. 140 Illustrations. Small 8vo, 2*s.* 6*d.* cloth.

"One of the most readable books extant on the Electric Telegraph."—*English Mechanic.*

DR. LARDNER'S MUSEUM OF SCIENCE AND ART.

THE MUSEUM OF SCIENCE AND ART. Edited by DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. With upwards of 1,200 Engravings on Wood. In 6 Double Volumes, £1 1s., in a new and elegant cloth binding; or handsomely bound in half-morocco, 31s. 6d.

*** OPINIONS OF THE PRESS.

"This series, besides affording popular but sound instruction on scientific subjects, with which the humblest man in the country ought to be acquainted, also undertakes that teaching of 'Common Things' which every well-wisher of his kind is anxious to promote. Many thousand copies of this serviceable publication have been printed, in the belief and hope that the desire for instruction and improvement widely prevails; and we have no fear that such enlightened faith will meet with disappointment."—*Times.*

"A cheap and interesting publication, alike informing and attractive. The papers combine subjects of importance and great scientific knowledge, considerable inductive powers, and a popular style of treatment."—*Spectator.*

"The 'Museum of Science and Art' is the most valuable contribution that has ever been made to the Scientific Instruction of every class of society."—Sir DAVID BREWSTER, in the *North British Review.*

"Whether we consider the liberality and beauty of the illustrations, the charm of the writing, or the durable interest of the matter, we must express our belief that there is hardly to be found among the new books one that would be welcomed by people of so many ages and classes as a valuable present."—*Examiner.*

*** *Separate books formed from the above, suitable for Workmen's Libraries, Science Classes, etc.*

Common Things Explained. Containing Air, Earth, Fire, Water, Time, Man, the Eye, Locomotion, Colour, Clocks and Watches, &c. 233 Illustrations, cloth gilt, 5s.

The Microscope. Containing Optical Images, Magnifying Glasses, Origin and Description of the Microscope, Microscopic Objects, the Solar Microscope, Microscopic Drawing and Engraving, &c. 147 Illustrations, cloth gilt, 2s.

Popular Geology. Containing Earthquakes and Volcanoes, the Crust of the Earth, &c. 201 Illustrations, cloth gilt, 2s. 6d.

Popular Physics. Containing Magnitude and Minuteness, the Atmosphere, Meteoric Stones, Popular Fallacies, Weather Prognostics, the Thermometer, the Barometer, Sound, &c. 85 Illustrations, cloth gilt, 2s. 6d.

Steam and its Uses. Including the Steam Engine, the Locomotive, and Steam Navigation. 89 Illustrations, cloth gilt, 2s.

Popular Astronomy. Containing How to observe the Heavens—The Earth, Sun, Moon, Planets, Light, Comets, Eclipses, Astronomical Influences, &c. 182 Illustrations, 4s. 6d.

The Bee and White Ants: Their Manners and Habits. With Illustrations of Animal Instinct and Intelligence. 135 Illustrations, cloth gilt, 2s.

The Electric Telegraph Popularized. To render intelligible to all who can Read, irrespective of any previous Scientific Acquirements, the various forms of Telegraphy in Actual Operation. 100 Illustrations, cloth gilt, 1s. 6d.

Dr. Lardner's School Handbooks.

NATURAL PHILOSOPHY FOR SCHOOLS. By Dr. LARDNER. 328 Illustrations. Sixth Edition. One Vol., 3s. 6d. cloth.

"A very convenient class-book for junior students in private schools. It is intended to convey, in clear and precise terms, general notions of all the principal divisions of Physical Science."—*British Quarterly Review.*

ANIMAL PHYSIOLOGY FOR SCHOOLS. By Dr. LARDNER. With 190 Illustrations. Second Edition. One Vol., 3s. 6d. cloth.

"Clearly written, well arranged, and excellently illustrated."—*Gardener's Chronicle.*

COUNTING-HOUSE WORK, TABLES, etc.

Introduction to Business.

LESSONS IN COMMERCE. By Professor R. GAMBARO, of the Royal High Commercial School at Genoa. Edited and Revised by JAMES GAULT, Professor of Commerce and Commercial Law in King's College, London. Crown 8vo, price about 3s. 6*d*. [*In the press.*

Accounts for Manufacturers.

FACTORY ACCOUNTS: Their Principles and Practice. A Handbook for Accountants and Manufacturers, with Appendices on the Nomenclature of Machine Details; the Income Tax Acts; the Rating of Factories; Fire and Boiler Insurance; the Factory and Workshop Acts, &c., including also a Glossary of Terms and a large number of Specimen Rulings. By EMILE GARCKE and J. M. FELLS. Third Edition. Demy 8vo, 250 pages, price 6s. strongly bound.

"A very interesting description of the requirements of Factory Accounts. . . . the principle of assimilating the Factory Accounts to the general commercial books is one which we thoroughly agree with."—*Accountants' Journal.*

"There are few owners of Factories who would not derive great benefit from the perusal of this most admirable work."—*Local Government Chronicle.*

Foreign Commercial Correspondence.

THE FOREIGN COMMERCIAL CORRESPONDENT: Being Aids to Commercial Correspondence in Five Languages—English, French, German, Italian and Spanish. By CONRAD E. BAKER. Second Edition, Revised. Crown 8vo, 3s. 6d. cloth.

"Whoever wishes to correspond in all the languages mentioned by Mr. Baker cannot do better than study this work, the materials of which are excellent and conveniently arranged."—*Athenæum.*

"A careful examination has convinced us that it is unusually complete, well arranged and reliable. The book is a thoroughly good one."—*Schoolmaster.*

Intuitive Calculations.

THE COMPENDIOUS CALCULATOR; or, Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions, together with Useful Tables. By D. O'GORMAN. Corrected by Professor J. R. YOUNG. Twenty-seventh Ed., Revised by C. NORRIS. Fcap. 8vo, 2s. 6*d*. cloth; or, 3s. 6*d*. half-bound.

"It would be difficult to exaggerate the usefulness of a book like this to everyone engaged in commerce or manufacturing industry."—*Knowledge.*

"Supplies special and rapid methods for all kinds of calculations. Of great utility to persons engaged in any kind of commercial transactions."—*Scotsman.*

Modern Metrical Units and Systems.

MODERN METROLOGY: A Manual of the Metrical Units and Systems of the Present Century. With an Appendix containing a proposed English System. By LOWIS D'A. JACKSON, A.M.Inst.C.E., Author of "Aid to Survey Practice," &c. Large crown 8vo, 12s. 6*d*. cloth.

"The author has brought together much valuable and interesting information. . . . We cannot but recommend the work."—*Nature.*

"For exhaustive tables of equivalent weights and measures of all sorts, and for clear demonstrations of the effects of the various systems that have been proposed or adopted, Mr. Jackson's treatise is without a rival."—*Academy.*

The Metric System and the British Standards.

A SERIES OF METRIC TABLES, in which the British Standard Measures and Weights are compared with those of the Metric System at present in Use on the Continent. By C. H. DOWLING, C.E. 8vo, 10s. 6*d*. strongly bound.

"Their accuracy has been certified by Professor Airy, the Astronomer-Royal."—*Builder.*

"Mr. Dowling's Tables are well put together as a ready-reckoner for the conversion of one system into the other."—*Athenæum.*

Iron and Metal Trades' Calculator.

THE IRON AND METAL TRADES' COMPANION. For expeditiously ascertaining the Value of any Goods bought or sold by Weight, from 1s. per cwt. to 112s. per cwt., and from one farthing per pound to one shilling per pound. Each Table extends from one pound to 100 tons. To which are appended Rules on Decimals, Square and Cube Root, Mensuration of Superficies and Solids, &c.; also Tables of Weights of Materials, and other Useful Memoranda. By THOS. DOWNIE. Strongly bound in leather, 396 pp., 9s.

"A most useful set of tables. . . . Nothing like them before existed."—*Building News.*

"Although specially adapted to the iron and metal trades, the tables will be found useful in every other business in which merchandise is bought and sold by weight."—*Railway News.*

Calculator for Numbers and Weights Combined.

THE NUMBER, WEIGHT AND FRACTIONAL CALCULATOR. Containing upwards of 250,000 Separate Calculations, showing at a glance the value at 422 different rates, ranging from $\frac{1}{128}$th of a Penny to 20s. each, or per cwt., and £20 per ton, of any number of articles consecutively, from 1 to 470.—Any number of cwts., qrs., and lbs., from 1 cwt. to 470 cwts.—Any number of tons, cwts., qrs., and lbs., from 1 to 1,000 tons. By WILLIAM CHADWICK, Public Accountant. Third Edition, Revised and Improved. 8vo, price 18s., strongly bound for Office wear and tear.

*** *This work is specially adapted for the Apportionment of Mileage Charges for Railway Traffic.*

☞ *This comprehensive and entirely unique and original Calculator is adapted for the use of Accountants and Auditors, Railway Companies, Canal Companies, Shippers, Shipping Agents, General Carriers, etc.*

Ironfounders, Brassfounders, Metal Merchants, Iron Manufacturers, Ironmongers, Engineers, Machinists, Boiler Makers, Millwrights, Roofing, Bridge and Girder Makers, Colliery Proprietors, etc.

Timber Merchants, Builders, Contractors, Architects, Surveyors, Auctioneers Valuers, Brokers, Mill Owners and Manufacturers, Mill Furnishers, Merchants and General Wholesale Tradesmen.

*** OPINIONS OF THE PRESS.

"The book contains the answers to questions, and not simply a set of ingenious puzzle methods of arriving at results. It is as easy of reference for any answer or any number of answers as a dictionary, and the references are even more quickly made. For making up accounts or estimates, the book must prove invaluable to all who have any considerable quantity of calculations involving price and measure in any combination to do."—*Engineer.*

"The most perfect work of the kind yet prepared."—*Glasgow Herald.*

Comprehensive Weight Calculator.

THE WEIGHT CALCULATOR. Being a Series of Tables upon a New and Comprehensive Plan, exhibiting at One Reference the exact Value of any Weight from 1 lb. to 15 tons, at 300 Progressive Rates, from 1*d.* to 168*s.* per cwt., and containing 186,000 Direct Answers, which, with their Combinations, consisting of a single addition (mostly to be performed at sight), will afford an aggregate of 10,266,000 Answers; the whole being calculated and designed to ensure correctness and promote despatch. By HENRY HARBEN, Accountant. Fourth Edition, carefully Corrected. Royal 8vo, strongly half-bound, £1 5*s.*

"A practical and useful work of reference for men of business generally; it is the best of the kind we have seen.'—*Ironmonger.*

"Of priceless value to business men. It is a necessary book in all mercantile offices."—*Sheffield Independent.*

Comprehensive Discount Guide.

THE DISCOUNT GUIDE. Comprising several Series of Tables for the use of Merchants, Manufacturers, Ironmongers, and others, by which may be ascertained the exact Profit arising from any mode of using Discounts, either in the Purchase or Sale of Goods, and the method of either Altering a Rate of Discount or Advancing a Price, so as to produce, by one operation, a sum that will realise any required profit after allowing one or more Discounts: to which are added Tables of Profit or Advance from 1¼ to 90 per cent., Tables of Discount from 1¼ to 98¾ per cent., and Tables of Commission, &c., from ⅛ to 10 per cent. By HENRY HARBEN, Accountant, Author of "The Weight Calculator." New Edition, carefully Revised and Corrected. Demy 8vo, 544 pp. half-bound, £1 5*s.*

"A book such as this can only be appreciated by business men, to whom the saving of time means saving of money. We have the high authority of Professor J. R. Young that the tables throughout the work are constructed upon strictly accurate principles. The work is a mode of typographical clearness, and must prove of great value to merchants, manufacturers, and general traders."—*British Trade Journal.*

Iron Shipbuilders' and Merchants' Weight Tables.

IRON-PLATE WEIGHT TABLES: For Iron Shipbuilders, Engineers and Iron Merchants. Containing the Calculated Weights of upwards of 150,000 different sizes of Iron Plates, from 1 foot by 6 in. by ¼ in. to 10 feet by 5 feet by 1 in. Worked out on the basis of 40 lbs. to the square foot of Iron of 1 inch in thickness. Carefully compiled and thoroughly Revised by H. BURLINSON and W. H. SIMPSON. Oblong 4to, 25*s.* half-bound.

"This work will be found of great utility. The authors have had much practical experience of what is wanting in making estimates; and the use of the book will save much time in making elaborate calculations."—*English Mechanic.*

INDUSTRIAL AND USEFUL ARTS.

Soap-making.

THE ART OF SOAP-MAKING: A Practical Handbook of the Manufacture of Hard and Soft Soaps, Toilet Soaps, etc. Including many New Processes, and a Chapter on the Recovery of Glycerine from Waste Leys. By ALEXANDER WATT, Author of "Electro-Metallurgy Practically Treated," &c. With numerous Illustrations. Fourth Edition, Revised and Enlarged. Crown 8vo, 7*s.* 6*d.* cloth.

"The work will prove very useful, not merely to the technological student, but to the practical soap-boiler who wishes to understand the theory of his art."—*Chemical News.*

"Mr. Watt's book is a thoroughly practical treatise on an art which has almost no literature in our language. We congratulate the author on the success of his endeavour to fill a void in English technical literature."—*Nature.*

Paper Making.

THE ART OF PAPER MAKING: A Practical Handbook of the Manufacture of Paper from Rags, Esparto, Straw and other Fibrous Materials, Including the Manufacture of Pulp from Wood Fibre, with a Description of the Machinery and Appliances used. To which are added Details of Processes for Recovering Soda from Waste Liquors. By ALEXANDER WATT. With Illustrations. Crown 8vo, 7*s.* 6*d.* cloth.

"This book is succinct, lucid, thoroughly practical, and includes everything of interest to the modern paper maker. It is the latest, most practical and most complete work on the paper-making art before the British public."—*Paper Record.*

"It may be regarded as the standard work on the subject. The book is full of valuable information. The 'Art of Paper-making,' is in every respect a model of a text-book, either for a technical class or for the private student."—*Paper and Printing Trades Journal.*

"Admirably adapted for general as well as ordinary technical reference, and as a handbook for students in technical education may be warmly commended."—*The Paper Maker's Monthly Journal.*

Leather Manufacture.

THE ART OF LEATHER MANUFACTURE. Being a Practical Handbook, in which the Operations of Tanning, Currying, and Leather Dressing are fully Described, the Principles of Tanning Explained and many Recent Processes introduced. By ALEXANDER WATT, Author of "Soap-Making," &c. With numerous Illustrations. Second Edition. Crown 8vo, 9*s.* cloth.

"A sound, comprehensive treatise on tanning and its accessories. This book is an eminently valuable production, which redounds to the credit of both author and publishers."—*Chemical Review.*

"This volume is technical without being tedious, comprehensive and complete without being prosy, and it bears on every page the impress of a master hand. We have never come across a better trade treatise, nor one that so thoroughly supplied an absolute want."—*Shoe and Leather Trades' Chronicle.*

Boot and Shoe Making.

THE ART OF BOOT AND SHOE-MAKING. A Practical Handbook, including Measurement, Last-Fitting, Cutting-Out, Closing and Making, with a Description of the most approved Machinery employed. By JOHN B. LENO, late Editor of *St. Crispin*, and *The Boot and Shoe-Maker.* With numerous Illustrations. Third Edition. 12mo, 2*s.* cloth limp.

"This excellent treatise is by far the best work ever written on the subject. A new work, embracing all modern improvements, was much wanted. This want is now satisfied. The chapter on clicking, which shows how waste may be prevented, will save fifty times the price of the book."—*Scottish Leather Trader.*

Dentistry.

MECHANICAL DENTISTRY: A Practical Treatise on the Construction of the various kinds of Artificial Dentures. Comprising also Useful Formulæ, Tables and Receipts for Gold Plate, Clasps, Solders, &c. &c. By CHARLES HUNTER. Third Edition, Revised. With upwards of 100 Wood Engravings. Crown 8vo, 3*s.* 6*d.* cloth.

"The work is very practical."—*Monthly Review of Dental Surgery.*

"We can strongly recommend Mr. Hunter's treatise to all students preparing for the profession of dentistry, as well as to every mechanical dentist."—*Dublin Journal of Medical Science.*

Wood Engraving.

WOOD ENGRAVING: A Practical and Easy Introduction to the Study of the Art. By WILLIAM NORMAN BROWN. Second Edition. With numerous Illustrations. 12mo, 1*s.* 6*d.* cloth limp.

"The book is clear and complete, and will be useful to anyone wanting to understand the first elements of the beautiful art of wood engraving."—*Graphic.*

HANDYBOOKS FOR HANDICRAFTS. By PAUL N. HASLUCK.

Metal Turning.

THE METAL TURNER'S HANDYBOOK. A Practical Manual for Workers at the Foot-Lathe: Embracing Information on the Tools, Appliances and Processes employed in Metal Turning. By PAUL N. HASLUCK, Author of "Lathe-Work." With upwards of One Hundred Illustrations. Second Edition, Revised. Crown 8vo, 2*s.* cloth.

"Clearly and concisely written, excellent in every way."—*Mechanical World.*

Wood Turning.

THE WOOD TURNER'S HANDYBOOK. A Practical Manual for Workers at the Lathe: Embracing Information on the Tools, Appliances and Processes Employed in Wood Turning. By PAUL N. HASLUCK. With upwards of One Hundred Illustrations. Crown 8vo, 2*s.* cloth.

"We recommend the book to young turners and amateurs. A multitude of workmen have hitherto sought in vain for a manual of this special industry."—*Mechanical World.*

WOOD AND METAL TURNING. By P. N. HASLUCK. (Being the Two preceding Vols. bound together.) 300 pp., with upwards of 200 Illustrations, crown 8vo, 3*s.* 6*d.* cloth.

Watch Repairing.

THE WATCH JOBBER'S HANDYBOOK. A Practical Manual on Cleaning, Repairing and Adjusting. Embracing Information on the Tools, Materials, Appliances and Processes Employed in Watchwork. By PAUL N. HASLUCK. With upwards of One Hundred Illustrations. Cr. 8vo, 2*s.* cloth.

"All young persons connected with the trade should acquire and study this excellent, and at the same time, inexpensive work."—*Clerkenwell Chronicle.*

Clock Repairing.

THE CLOCK JOBBER'S HANDYBOOK: A Practical Manual on Cleaning, Repairing and Adjusting. Embracing Information on the Tools, Materials, Appliances and Processes Employed in Clockwork. By PAUL N. HASLUCK. With upwards of 100 Illustrations. Cr. 8vo, 2*s.* cloth.

"Of inestimable service to those commencing the trade."—*Coventry Standard.*

WATCH AND CLOCK JOBBING. By P. N. HASLUCK. (Being the Two preceding Vols. bound together.) 320 pp., with upwards of 200 Illustrations, crown 8vo, 3*s.* 6*d.* cloth.

Pattern Making.

THE PATTERN MAKER'S HANDYBOOK. A Practical Manual, embracing Information on the Tools, Materials and Appliances employed in Constructing Patterns for Founders. By PAUL N. HASLUCK. With One Hundred Illustrations. Crown 8vo, 2*s.* cloth.

"This handy volume contains sound information of considerable value to students and artificers."—*Hardware Trades Journal.*

Mechanical Manipulation.

THE MECHANIC'S WORKSHOP HANDYBOOK. A Practical Manual on Mechanical Manipulation. Embracing Information on various Handicraft Processes, with Useful Notes and Miscellaneous Memoranda. By PAUL N. HASLUCK. Crown 8vo, 2*s.* cloth.

"It is a book which should be found in every workshop, as it is one which will be continually referred to for a very great amount of standard information."—*Saturday Review.*

Model Engineering.

THE MODEL ENGINEER'S HANDYBOOK: A Practical Manual on Model Steam Engines. Embracing Information on the Tools, Materials and Processes Employed in their Construction. By PAUL N. HASLUCK. With upwards of 100 Illustrations. Crown 8vo, 2*s.* cloth.

"By carefully going through the work, amateurs may pick up an excellent notion of the construction of full-sized steam engines."—*Telegraphic Journal.*

Cabinet Making.

THE CABINET WORKER'S HANDYBOOK: A Practical Manual, embracing Information on the Tools, Materials, Appliances and Processes employed in Cabinet Work. By PAUL N. HASLUCK, Author of "Lathe Work," &c. With upwards of 100 Illustrations. Crown 8vo, 2*s.* cloth.

"Thoroughly practical throughout. The amateur worker in wood w.l find it most useful."—[*Glasgow Herald.*

Electrolysis of Gold, Silver, Copper, etc.

ELECTRO-DEPOSITION: A Practical Treatise on the Electrolysis of Gold, Silver, Copper, Nickel, and other Metals and Alloys. With descriptions of Voltaic Batteries, Magneto and Dynamo-Electric Machines, Thermopiles, and of the Materials and Processes used in every Department of the Art, and several Chapters on Electro-Metallurgy. By ALEXANDER WATT. Third Edition, Revised and Corrected. Crown 8vo, 9*s*. cloth.

"Eminently a book for the practical worker in electro-deposition. It contains practical descriptions of methods, processes and materials as actually pursued and used in the workshop."—*Engineer.*

Electro-Metallurgy.

ELECTRO-METALLURGY; Practically Treated. By ALEXANDER WATT, Author of "Electro-Deposition," &c. Ninth Edition, Enlarged and Revised, with Additional Illustrations, and including the most recent Processes. 12mo, 4*s*. cloth boards.

"From this book both amateur and artisan may learn everything necessary for the successful prosecution of electroplating."—*Iron.*

Electroplating.

ELECTROPLATING: A Practical Handbook on the Deposition of Copper, Silver, Nickel, Gold, Aluminium, Brass, Platinum, &c. &c. With Descriptions of the Chemicals, Materials, Batteries and Dynamo Machines used in the Art. By J. W. URQUHART, C.E. Second Edition, with Additions. Numerous Illustrations. Crown 8vo, 5*s*. cloth.

"An excellent practical manual."—*Engineering.*

"An excellent work, giving the newest information."—*Horological Journal.*

Electrotyping.

ELECTROTYPING: The Reproduction and Multiplication of Printing Surfaces and Works of Art by the Electro-deposition of Metals. By J. W. URQUHART, C.E. Crown 8vo, 5*s*. cloth.

"The book is thoroughly practical. The reader is, therefore, conducted through the leading laws of electricity, then through the metals used by electrotypers, the apparatus, and the depositing processes, up to the final preparation of the work."—*Art Journal.*

Horology.

A TREATISE ON MODERN HOROLOGY, in Theory and Practice. Translated from the French of CLAUDIUS SAUNIER, by JULIEN TRIPPLIN, F.R.A.S., and EDWARD RIGG, M.A., Assayer in the Royal Mint. With 78 Woodcuts and 22 Coloured Plates. Second Edition. Royal 8vo, £2 2*s*. cloth; £2 10*s*. half-calf.

"There is no horological work in the English language at all to be compared to this production of M. Saunier's for clearness and completeness. It is alike good as a guide for the student and as a reference for the experienced horologist and skilled workman."—*Horological Journal.*

"The latest, the most complete, and the most reliable of those literary productions to which continental watchmakers are indebted for the mechanical superiority over their English brethren—in fact, the Book of Books, is M. Saunier's 'Treatise.'"—*Watchmaker, Jeweller and Silversmith.*

Watchmaking.

THE WATCHMAKER'S HANDBOOK. A Workshop Companion for those engaged in Watchmaking and the Allied Mechanical Arts. From the French of CLAUDIUS SAUNIER. Enlarged by JULIEN TRIPPLIN, F.R.A.S., and EDWARD RIGG, M.A., Assayer in the Royal Mint. Woodcuts and Copper Plates. Third Edition, Revised. Crown 8vo, 9*s*. cloth.

"Each part is truly a treatise in itself. The arrangement is good and the language is clear and concise. It is an admirable guide for the young watchmaker."—*Engineering.*

"It is impossible to speak too highly of its excellence. It fulfils every requirement in a handbook intended for the use of a workman."—*Watch and Clockmaker.*

"This book contains an immense number of practical details bearing on the daily occupation of a watchmaker."—*Watchmaker and Metalworker* (Chicago).

Goldsmiths' Work.

THE GOLDSMITH'S HANDBOOK. By GEORGE E. GEE, Jeweller, &c. Third Edition, considerably Enlarged. 12mo, 3*s*. 6*d*. cl. bds.

"A good, sound educator, and will be accepted as an authority."—*Horological Journal.*

Silversmiths' Work.

THE SILVERSMITH'S HANDBOOK. By GEORGE E. GEE, Jeweller, &c. Second Edition, Revised, with numerous Illustrations. 12mo, 3*s*. 6*d*. cloth boards.

"Workers in the trade will speedily discover its merits when they sit down to study it."—*English Mechanic.*

*** *The above two works together, strongly half-bound, price 7s.*

Bread and Biscuit Baking.

THE BREAD AND BISCUIT BAKER'S AND SUGAR-BOILER'S ASSISTANT. Including a large variety of Modern Recipes. With Remarks on the Art of Bread-making. By ROBERT WELLS, Practical Baker. Second Edition, with Additional Recipes. Crown 8vo, 2*s.* cloth.

"A large number of wrinkles for the ordinary cook, as well as the baker."—*Saturday Review.*

Confectionery.

THE PASTRYCOOK AND CONFECTIONER'S GUIDE. For Hotels, Restaurants and the Trade in general, adapted also for Family Use. By ROBERT WELLS, Author of "The Bread and Biscuit Baker's and Sugar Boiler's Assistant." Crown 8vo, 2*s.* cloth.

"We cannot speak too highly of this really excellent work. In these days of keen competition our readers cannot do better than purchase this book."—*Bakers' Times.*

Ornamental Confectionery.

ORNAMENTAL CONFECTIONERY: A Guide for Bakers, Confectioners and Pastrycooks; including a variety of Modern Recipes, and Remarks on Decorative and Coloured Work. With 129 Original Designs. By ROBERT WELLS. Crown 8vo, 5*s.* cloth.

"A valuable work, and should be in the hands of every baker and confectioner. The illustrative designs are alone worth treble the amount charged for the whole work."—*Bakers' Times.*

Flour Confectionery.

THE MODERN FLOUR CONFECTIONER. Wholesale and Retail. Containing a large Collection of Recipes for Cheap Cakes, Biscuits, &c. With Remarks on the Ingredients used in their Manufacture, &c. By R. WELLS, Author of "Ornamental Confectionery," "The Bread and Biscuit Baker," "The Pastrycook's Guide," &c. Crown 8vo, 2*s.* cloth.

Laundry Work.

LAUNDRY MANAGEMENT. A Handbook for Use in Private and Public Laundries, Including Descriptive Accounts of Modern Machinery and Appliances for Laundry Work. By the EDITOR of "The Laundry Journal." With numerous Illustrations. Crown 8vo, 2*s.* 6*d.* cloth.

CHEMICAL MANUFACTURES & COMMERCE.

New Manual of Engineering Chemistry.

ENGINEERING CHEMISTRY: A Practical Treatise for the Use of Analytical Chemists, Engineers, Iron Masters, Iron Founders, Students, and others. Comprising Methods of Analysis and Valuation of the Principal Materials used in Engineering Work, with numerous Analyses, Examples, and Suggestions. By H. JOSHUA PHILLIPS, F.I.C., F.C.S. Analytical and Consulting Chemist to the Great Eastern Railway. Crown 8vo 320 pp., with Illustrations, 10*s.* 6*d.* cloth. [*Just published.*

"In this work the author has rendered no small service to a numerous body of practical men . . . The analytical methods may be pronounced most satisfactory, being as accurate as the despatch required of engineering chemists permits."—*Chemical News.*

Analysis and Valuation of Fuels.

FUELS: SOLID, LIQUID AND GASEOUS, Their Analysis and Valuation. For the Use of Chemists and Engineers. By H. J. PHILLIPS, F.C.S., Analytical and Consulting Chemist to the Great Eastern Railway. Crown 8vo, 3*s.* 6*d.* cloth.

"Ought to have its place in the laboratory of every metallurgical establishment, and wherever fuel is used on a large scale."—*Chemical News.*

"Cannot fail to be of wide interest, especially at the present time."—*Railway News.*

Alkali Trade, Manufacture of Sulphuric Acid, etc.

A MANUAL OF THE ALKALI TRADE, including the Manufacture of Sulphuric Acid, Sulphate of Soda, and Bleaching Powder. By JOHN LOMAS. 390 pages. With 232 Illustrations and Working Drawings. Second Edition. Royal 8vo, £1 10*s.* cloth.

"This book is written by a manufacturer for manufacturers. The working details of the most approved forms of apparatus are given, and these are accompanied by no less than 232 wood engravings, all of which may be used for the purposes of construction."—*Athenæum.*

The Blowpipe.

THE BLOWPIPE IN CHEMISTRY, MINERALOGY, AND GEOLOGY. Containing all known Methods of Anhydrous Analysis, Working Examples, and Instructions for Making Apparatus. By Lieut.-Col. W. A Ross, R.A. With 120 Illustrations. New Edition. Crown 8vo, 5s. cloth.

"The student who goes through the course of experimentation here laid down will gain a better insight into inorganic chemistry and mineralogy than if he had 'got up' any of the best text-books of the day, and passed any number of examinations in their contents."—*Chemical News.*

Commercial Chemical Analysis.

THE COMMERCIAL HANDBOOK OF CHEMICAL ANALYSIS; or, Practical Instructions for the determination of the Intrinsic or Commercial Value of Substances used in Manufactures, Trades, and the Arts. By A. Normandy. New Edition by H. M. Noad, F.R.S. Cr. 8vo, 12s. 6d. cl.

"Essential to the analysts appointed under the new Act. The most recent results are given, and the work is well edited and carefully written."—*Nature.*

Brewing.

A HANDBOOK FOR YOUNG BREWERS. By Herbert Edwards Wright, B.A. New Edition, much Enlarged. [*In the press.*

Dye-Wares and Colours.

THE MANUAL OF COLOURS AND DYE-WARES: Their Properties, Applications, Valuation, Impurities, and Sophistications. For the use of Dyers, Printers, Drysalters, Brokers, &c. By J. W. Slater. Second Edition, Revised and greatly Enlarged. Crown 8vo, 7s. 6d. cloth.

"A complete encyclopædia of the *materia tinctoria*. The information given respecting each article is full and precise, and the methods of determining the value of articles such as these, so liable to sophistication, are given with clearness, and are practical as well as valuable."—*Chemist and Druggist.*

"There is no other work which covers precisely the same ground. To students preparing for examinations in dyeing and printing it will prove exceedingly useful."—*Chemical News.*

Pigments.

THE ARTIST'S MANUAL OF PIGMENTS. Showing their Composition, Conditions of Permanency, Non-Permanency, and Adulterations; Effects in Combination with Each Other and with Vehicles; and the most Reliable Tests of Purity. By H. C. Standage. Second Edition. Crown 8vo, 2s. 6d. cloth.

"This work is indeed *multum-in-parvo*, and we can, with good conscience, recommend it to all who come in contact with pigments, whether as makers, dealers or users."—*Chemical Review.*

Gauging. Tables and Rules for Revenue Officers, Brewers, etc.

A POCKET BOOK OF MENSURATION AND GAUGING: Containing Tables, Rules and Memoranda for Revenue Officers, Brewers, Spirit Merchants, &c. By J. B. Mant (Inland Revenue). Second Edition Revised. Oblong 18mo, 4s. leather, with elastic band.

"This handy and useful book is adapted to the requirements of the Inland Revenue Department, and will be a favourite book of reference."—*Civilian.*

"Should be in the hands of every practical brewer."—*Brewers' Journal.*

AGRICULTURE, FARMING, GARDENING, etc.

Youatt and Burn's Complete Grazier.

THE COMPLETE GRAZIER, and FARMER'S and CATTLE-BREEDER'S ASSISTANT. Including the Breeding, Rearing, and Feeding of Stock; Management of the Dairy, Culture and Management of Grass Land, and of Grain and Root Crops, &c. By W. Youatt and R. Scott Burn. An entirely New Edition, partly Re-written and greatly Enlarged, by W. Fream, B.Sc.Lond., LL.D. In medium 8vo, about 1,000 pp. [*In the press.*

Agricultural Facts and Figures.

NOTE-BOOK OF AGRICULTURAL FACTS AND FIGURES FOR FARMERS AND FARM STUDENTS. By Primrose McConnell, late Professor of Agriculture, Glasgow Veterinary College. Third Edition Royal 32mo, 4s. leather.

"The most complete and comprehensive Note-book for Farmers and Farm Students that we have seen. It literally teems with information, and we can cordially recommend it to all connected with agriculture."—*North British Agriculturist.*

Flour Manufacture, Milling, etc.

FLOUR MANUFACTURE: A Treatise on Milling Science and Practice. By FRIEDRICH KICK, Imperial Regierungsrath, Professor of Mechanical Technology in the Imperial German Polytechnic Institute, Prague. Translated from the Second Enlarged and Revised Edition with Supplement. By H. H. P. POWLES, A.M.I.C.E. Nearly 400 pp. Illustrated with 28 Folding Plates, and 167 Woodcuts. Royal 8vo, 25*s.* cloth.

"This valuable work is, and will remain, the standard authority on the science of milling. . . The miller who has read and digested this work will have laid the foundation, so to speak, of a successful career; he will have acquired a number of general principles which he can proceed to apply. In this handsome volume we at last have the accepted text-book of modern milling in good, sound English, which has little, if any, trace of the German idiom."—*The Miller.*

"The appearance of this celebrated work in English is very opportune, and British millers will, we are sure, not be slow in availing themselves of its pages."—*Millers' Gazette.*

Small Farming.

SYSTEMATIC SMALL FARMING; or, The Lessons of my Farm. Being an Introduction to Modern Farm Practice for Small Farmers in the Culture of Crops; The Feeding of Cattle; The Management of the Dairy, Poultry and Pigs, &c. &c. By ROBERT SCOTT BURN, Author of "Outlines of Landed Estates' Management." Numerous Illusts., cr. 8vo, 6*s.* cloth.

"This is the completest book of its class we have seen, and one which every amateur farmer will read with pleasure and accept as a guide."—*Field.*

"The volume contains a vast amount of useful information. No branch of farming is left untouched, from the labour to be done to the results achieved. It may be safely recommended to all who think they will be in paradise when they buy or rent a three-acre farm."—*Glasgow Herald.*

Modern Farming.

OUTLINES OF MODERN FARMING. By R. SCOTT BURN. Soils, Manures, and Crops—Farming and Farming Economy—Cattle, Sheep, and Horses — Management of Dairy, Pigs and Poultry — Utilisation of Town-Sewage, Irrigation, &c. Sixth Edition. In One Vol., 1,250 pp., half-bound, profusely Illustrated, 12*s.*

"The aim of the author has been to make his work at once comprehensive and trustworthy, and in this aim he has succeeded to a degree which entitles him to much credit."—*Morning Advertiser.* "No farmer should be without this book."—*Banbury Guardian.*

Agricultural Engineering.

FARM ENGINEERING, THE COMPLETE TEXT-BOOK OF. Comprising Draining and Embanking; Irrigation and Water Supply; Farm Roads, Fences, and Gates; Farm Buildings, their Arrangement and Construction, with Plans and Estimates; Barn Implements and Machines; Field Implements and Machines; Agricultural Surveying, Levelling, &c. By Prof. JOHN SCOTT, Editor of the "Farmers' Gazette," late Professor of Agriculture and Rural Economy at the Royal Agricultural College, Cirencester, &c. &c. In One Vol., 1,150 pages, half-bound, with over 600 Illustrations, 12*s.*

"Written with great care, as well as with knowledge and ability. The author has done his work well; we have found him a very trustworthy guide wherever we have tested his statements. The volume will be of great value to agricultural students."—*Mark Lane Express.*

"For a young agriculturist we know of no handy volume likely to be more usefully studied." —*Bell's Weekly Messenger.*

English Agriculture.

THE FIELDS OF GREAT BRITAIN: A Text-Book of Agriculture, adapted to the Syllabus of the Science and Art Department. For Elementary and Advanced Students. By HUGH CLEMENTS (Board of Trade). Second Ed., Revised, with Additions. 18mo, 2*s.* 6*d.* cl.

"A most comprehensive volume, giving a mass of information."—*Agricultural Economist.*

"It is a long time since we have seen a book which has pleased us more, or which contains such a vast and useful fund of knowledge."—*Educational Times.*

Tables for Farmers, etc.

TABLES, MEMORANDA, AND CALCULATED RESULTS for Farmers, Graziers, Agricultural Students, Surveyors, Land Agents Auctioneers, etc. With a New System of Farm Book-keeping. Selected and Arranged by SIDNEY FRANCIS. Second Edition, Revised. 272 pp., waistcoat-pocket size, 1*s.* 6*d.* limp leather.

"Weighing less than 1 oz., and occupying no more space than a match box, it contains a mass of facts and calculations which has never before, in such handy form, been obtainable. Every operation on the farm is dealt with. The work may be taken as thoroughly accurate, the whole of the tables having been revised by Dr. Fream. We cordially recommend it."—*Bell's Weekly Messenger.*

"A marvellous little book. . . . The agriculturist who possesses himself of it will not be disappointed with his investment."—*The Farm.*

Farm and Estate Book-keeping.

BOOK-KEEPING FOR FARMERS & ESTATE OWNERS. A Practical Treatise, presenting, in Three Plans, a System adapted for all Classes of Farms. By JOHNSON M. WOODMAN, Chartered Accountant. Second Edition, Revised. Cr. 8vo, 3*s*. 6*d*. cl. bds.; or 2*s*. 6*d*. cl. limp.

"The volume is a capital study of a most important subject."—*Agricultural Gazette.*

"Will be found of great assistance by those who intend to commence a system of book-keeping, the author's examples being clear and explicit, and his explanations, while full and accurate, being to a large extent free from technicalities."—*Live Stock Journal.*

Farm Account Book.

WOODMAN'S YEARLY FARM ACCOUNT BOOK. Giving a Weekly Labour Account and Diary, and showing the Income and Expenditure under each Department of Crops, Live Stock, Dairy, &c. &c. With Valuation, Profit and Loss Account, and Balance Sheet at the end of the Year, and an Appendix of Forms. Ruled and Headed for Entering a Complete Record of the Farming Operations. By JOHNSON M. WOODMAN, Chartered Accountant. Folio, 7*s*. 6*d*. half-bound.

"Contains every requisite form for keeping farm accounts readily and accurately."—*Agriculture.*

Early Fruits, Flowers and Vegetables.

THE FORCING GARDEN; or, How to Grow Early Fruits, Flowers, and Vegetables. With Plans and Estimates for Building Glass-houses, Pits and Frames. By SAMUEL WOOD. Crown 8vo, 3*s*. 6*d*. cloth.

"A good book, and fairly fills a place that was in some degree vacant. The book is written with great care, and contains a great deal of valuable teaching."—*Gardeners' Magazine.*

"Mr. Wood's book is an original and exhaustive answer to the question 'How to Grow Early Fruits, Flowers and Vegetables?'"—*Land and Water.*

Good Gardening.

A PLAIN GUIDE TO GOOD GARDENING; or, How to Grow Vegetables, Fruits, and Flowers. With Practical Notes on Soils, Manures, Seeds, Planting, Laying-out of Gardens and Grounds, &c. By S. WOOD. Fourth Edition, with numerous Illustrations. Crown 8vo, 3*s*. 6*d*. cloth.

"A very good book, and one to be highly recommended as a practical guide. The practical directions are excellent."—*Athenæum.*

"May be recommended to young gardeners, cottagers, and specially to amateurs, for the plain, simple, and trustworthy information it gives on common matters too often neglected."—*Gardeners' Chronicle.*

Gainful Gardening.

MULTUM-IN-PARVO GARDENING; or, How to make One Acre of Land produce £620 a-year by the Cultivation of Fruits and Vegetables; also, How to Grow Flowers in Three Glass Houses, so as to realise £176 per annum clear Profit. By S. WOOD. Fifth Edition. Crown 8vo, 1*s*. sewed.

"We are bound to recommend it as not only suited to the case of the amateur and gentleman's gardener, but to the market grower."—*Gardeners' Magazine.*

Gardening for Ladies.

THE LADIES' MULTUM-IN-PARVO FLOWER GARDEN, and Amateurs' Complete Guide. By S. WOOD. With Illusts. Cr. 8vo, 3*s*. 6*d*. cl.

"This volume contains a good deal of sound, common sense instruction."—*Florist.*

"Full of shrewd hints and useful instructions, based on a lifetime of experience."—*Scotsman.*

Receipts for Gardeners.

GARDEN RECEIPTS. By C. W. QUIN. 12mo, 1*s*. 6*d*. cloth.

"A useful and handy book, containing a good deal of valuable information."—*Athenæum.*

Market Gardening.

MARKET AND KITCHEN GARDENING. By Contributors to "The Garden." Compiled by C. W. SHAW, late Editor of "Gardening Illustrated." 12mo, 3*s*. 6*d*. cloth boards.

"The most valuable compendium of kitchen and market-garden work published."—*Farmer.*

Cottage Gardening.

COTTAGE GARDENING; or, Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAY. 12mo, 1*s*. 6*d*. cloth limp.

Potato Culture.

POTATOES: How to Grow and Show Them. A Practical Guide to the Cultivation and General Treatment of the Potato. By JAMES PINK. Second Edition. Crown 8vo, 2*s*. cloth.

LAND AND ESTATE MANAGEMENT, LAW, etc.

Hudson's Land Valuer's Pocket-Book.

THE LAND VALUER'S BEST ASSISTANT: Being Tables on a very much Improved Plan, for Calculating the Value of Estates. With Tables for reducing Scotch, Irish, and Provincial Customary Acres to Statute Measure, &c. By R. HUDSON, C.E. New Edition. Royal 32mo, leather, elastic band, 4*s.*

"This new edition includes tables for ascertaining the value of leases for any term of years; and for showing how to lay out plots of ground of certain acres in forms, square, round, &c., with valuable rules for ascertaining the probable worth of standing timber to any amount; and is of incalculable value to the country gentleman and professional man."—*Farmers' Journal.*

Ewart's Land Improver's Pocket-Book.

THE LAND IMPROVER'S POCKET-BOOK OF FORMULÆ, TABLES and MEMORANDA required in any Computation relating to the Permanent Improvement of Landed Property. By JOHN EWART, Land Surveyor and Agricultural Engineer. Second Edition, Revised. Royal 32mo, oblong, leather, gilt edges, with elastic band, 4*s.*

"A compendious and handy little volume."—*Spectator.*

Complete Agricultural Surveyor's Pocket-Book.

THE LAND VALUER'S AND LAND IMPROVER'S COMPLETE POCKET-BOOK. Consisting of the above Two Works bound together. Leather, gilt edges, with strap, 7*s.* 6*d.*

"Hudson's book is the best ready-reckoner on matters relating to the valuation of land and crops, and its combination with Mr. Ewart's work greatly enhances the value and usefulness of the latter-mentioned. . . . It is most useful as a manual for reference."—*North of England Farmer.*

Auctioneer's Assistant.

THE APPRAISER, AUCTIONEER, BROKER, HOUSE AND ESTATE AGENT AND VALUER'S POCKET ASSISTANT, for the Valuation for Purchase, Sale, or Renewal of Leases, Annuities and Reversions, and of property generally; with Prices for Inventories, &c. By JOHN WHEELER, Valuer, &c. Fifth Edition, re-written and greatly extended by C. NORRIS, Surveyor, Valuer, &c. Royal 32mo, 5*s.* cloth.

"A neat and concise book of reference, containing an admirable and clearly-arranged list of prices for inventories, and a very practical guide to determine the value of furniture, &c."—*Standard.*

"Contains a large quantity of varied and useful information as to the valuation for purchase, sale, or renewal of leases, annuities and reversions, and of property generally, with prices for inventories, and a guide to determine the value of interior fittings and other effects."—*Builder.*

Auctioneering.

AUCTIONEERS: THEIR DUTIES AND LIABILITIES. A Manual of Instruction and Counsel for the Young Auctioneer. By ROBERT SQUIBBS, Auctioneer. Second Edition, Revised and partly Re-written. Demy 8vo, 12*s.* 6*d.* cloth.

"The position and duties of auctioneers treated compendiously and clearly."—*Builder.*

"Every auctioneer ought to possess a copy of this excellent work."—*Ironmonger.*

"Of great value to the profession. . . . We readily welcome this book from the fact that it treats the subject in a manner somewhat new to the profession."—*Estates Gazette.*

Legal Guide for Pawnbrokers.

THE PAWNBROKERS', FACTORS' AND MERCHANTS' GUIDE TO THE LAW OF LOANS AND PLEDGES. With the Statutes and a Digest of Cases on Rights and Liabilities, Civil and Criminal, as to Loans and Pledges of Goods, Debentures, Mercantile and other Securities. By H. C. FOLKARD, Esq., Barrister-at-Law, Author of "The Law of Slander and Libel," &c. With Additions and Corrections. Fcap. 8vo, 3*s.* 6*d.* cloth.

"This work contains simply everything that requires to be known concerning the department of the law of which it treats. We can safely commend the book as unique and very nearly perfect." —*Iron.*

"The task undertaken by Mr. Folkard has been very satisfactorily performed. . . Such explanations as are needful have been supplied with great clearness and with due regard to brevity." *City Press.*

Law of Patents.

PATENTS FOR INVENTIONS, AND HOW TO PROCURE THEM. Compiled for the Use of Inventors, Patentees and others. By G. G. M. HARDINGHAM, Assoc.Mem.Inst.C.E., &c. Demy 8vo, cloth, price 2s. 6d.

Metropolitan Rating Appeals.

REPORTS OF APPEALS HEARD BEFORE THE COURT OF GENERAL ASSESSMENT SESSIONS, from the Year 1871 to 1885. By EDWARD RYDE and ARTHUR LYON RYDE. Fourth Edition, brought down to the Present Date, with an Introduction to the Valuation (Metropolis) Act, 1869, and an Appendix by WALTER C. RYDE, of the Inner Temple, Barrister-at-Law. 8vo, 16s. cloth.

"A useful work, occupying a place mid-way between a handbook for a lawyer and a guide to the surveyor. It is compiled by a gentleman eminent in his profession as a land agent, whose specialty, it is acknowledged, lies in the direction of assessing property for rating purposes."—*Land Agents' Record.*

"It is an indispensable work of reference for all engaged in assessment business."—*Journal of Gas Lighting.*

House Property.

HANDBOOK OF HOUSE PROPERTY. A Popular and Practical Guide to the Purchase, Mortgage, Tenancy, and Compulsory Sale of Houses and Land, including the Law of Dilapidations and Fixtures; with Examples of all kinds of Valuations, Useful Information on Building, and Suggestive Elucidations of Fine Art. By E. L. TARBUCK, Architect and Surveyor. Fourth Edition, Enlarged. 12mo, 5s. cloth.

"The advice is thoroughly practical."—*Law Journal.*

"For all who have dealings with house property, this is an indispensable guide."—*Decoration.*

"Carefully brought up to date, and much improved by the addition of a division on fine art.

"A well-written and thoughtful work."—*Land Agent's Record.*

Inwood's Estate Tables.

TABLES FOR THE PURCHASING OF ESTATES, Freehold, Copyhold, or Leasehold; Annuities, Advowsons, etc., and for the Renewing of Leases held under Cathedral Churches, Colleges, or other Corporate bodies, for Terms of Years certain, and for Lives; also for Valuing Reversionary Estates, Deferred Annuities, Next Presentations, &c.; together with SMART'S Five Tables of Compound Interest, and an Extension of the same to Lower and Intermediate Rates. By W. INWOOD. 23rd Edition, with considerable Additions, and new and valuable Tables of Logarithms for the more Difficult Computations of the Interest of Money, Discount, Annuities, &c., by M. FEDOR THOMAN, of the Société Crédit Mobilier of Paris. Crown 8vo, 8s. cloth.

"Those interested in the purchase and sale of estates, and in the adjustment of compensation cases, as well as in transactions in annuities, life insurances, &c., will find the present edition of eminent service."—*Engineering.*

"'Inwood's Tables' still maintain a most enviable reputation. The new issue has been enriched by large additional contributions by M. Fedor Thoman, whose carefully arranged Tables cannot fail to be of the utmost utility."—*Mining Journal.*

Agricultural and Tenant-Right Valuation.

THE AGRICULTURAL AND TENANT-RIGHT-VALUER'S ASSISTANT. A Practical Handbook on Measuring and Estimating the Contents, Weights and Values of Agricultural Produce and Timber, the Values of Estates and Agricultural Labour, Forms of Tenant-Right-Valuations, Scales of Compensation under the Agricultural Holdings Act, 1883, &c. &c. By TOM BRIGHT, Agricultural Surveyor. Crown 8vo, 3s. 6d. cloth.

"Full of tables and examples in connection with the valuation of tenant-right, estates, labour, contents, and weights of timber, and farm produce of all kinds."—*Agricultural Gazette.*

"An eminently practical handbook, full of practical tables and data of undoubted interest and value to surveyors and auctioneers in preparing valuations of all kinds."—*Farmer.*

Plantations and Underwoods.

POLE PLANTATIONS AND UNDERWOODS: A Practical Handbook on Estimating the Cost of Forming, Renovating, Improving and Grubbing Plantations and Underwoods, their Valuation for Purposes of Transfer, Rental, Sale or Assessment. By TOM BRIGHT, F.S.Sc., Author of "The Agricultural and Tenant-Right-Valuer's Assistant," &c. Crown 8vo, 3s. 6d. cloth. [*Just published.*

"Will be found very useful to those who are actually engaged in managing wood."—*Bell's Weekly Messenger.*

"To valuers, foresters and agents it will be a welcome aid."—*North British Agriculturist.*

"Well calculated to assist the valuer in the discharge of his duties, and of undoubted interest and use both to surveyors and auctioneers in preparing valuations of all kinds."—*Kent Herald.*

A Complete Epitome of the Laws of this Country.

EVERY MAN'S OWN LAWYER: A Handy-Book of the Principles of Law and Equity. By A BARRISTER. Twenty-ninth Edition. Revised and Enlarged. Including the Legislation of 1891, and including careful digests of *The Tithe Act*, 1891; the *Mortmain and Charitable Uses Act*, 1891; the *Charitable Trusts (Recovery) Act*, 1891; the *Forged Transfers Act*, 1891; the *Custody of Children Act*, 1891; the *Slander of Women Act*, 1891; the *Public Health (London) Act*, 1891; the *Stamp Act*, 1891; the *Savings Bank Act*, 1891; the *Elementary Education ("Free Education") Act*, 1891; the *County Councils (Elections) Act*, 1891; and the *Land Registry (Middlesex Deeds) Act*, 1891; while other new Acts have been duly noted. Crown 8vo, 688 pp., price 6s. 8*d.* (saved at every consultation!), strongly bound in cloth. [*Just published.*

*** THE BOOK WILL BE FOUND TO COMPRISE (AMONGST OTHER MATTER)—

THE RIGHTS AND WRONGS OF INDIVIDUALS—LANDLORD AND TENANT—VENDORS AND PURCHASERS—PARTNERS AND AGENTS—COMPANIES AND ASSOCIATIONS—MASTERS, SERVANTS AND WORKMEN—LEASES AND MORTGAGES—CHURCH AND CLERGY, RITUAL—LIBEL AND SLANDER—CONTRACTS AND AGREEMENTS—BONDS AND BILLS OF SALE—CHEQUES, BILLS AND NOTES—RAILWAY AND SHIPPING LAW—BANKRUPTCY AND INSURANCE—BORROWERS, LENDERS AND SURETIES—CRIMINAL LAW—PARLIAMENTARY ELECTIONS—COUNTY COUNCILS—MUNICIPAL CORPORATIONS—PARISH LAW, CHURCHWARDENS, ETC.—PUBLIC HEALTH AND NUISANCES—FRIENDLY AND BUILDING SOCIETIES—COPYRIGHT AND PATENTS—TRADE MARKS AND DESIGNS—HUSBAND AND WIFE, DIVORCE, ETC.—TRUSTEES AND EXECUTORS—INTESTACY, LAW OF—GUARDIAN AND WARD, INFANTS, ETC.—GAME LAWS AND SPORTING—HORSES, HORSE-DEALING AND DOGS—INNKEEPERS, LICENSING, ETC.—FORMS OF WILLS, AGREEMENTS, ETC. ETC.

NOTE.—*The object of this work is to enable those who consult it to help themselves to the law; and thereby to dispense, as far as possible, with professional assistance and advice. There are many wrongs and grievances which persons submit to from time to time through not knowing how or where to apply for redress; and many persons have as great a dread of a lawyer's office as of a lion's den. With this book at hand it is believed that many a* SIX-AND-EIGHTPENCE *may be saved; many a wrong redressed; many a right reclaimed; many a law suit avoided; and many an evil abated. The work has established itself as the standard legal adviser of all classes, and also made a reputation for itself as a useful book of reference for lawyers residing at a distance from law libraries, who are glad to have at hand a work embodying recent decisions and enactments.*

*** OPINIONS OF THE PRESS.

"It is a complete code of English Law, written in plain language, which all can understand. . . . Should be in the hands of every business man, and all who wish to abolish lawyers' bills."—*Weekly Times.*

"A useful and concise epitome of the law, compiled with considerable care."—*Law Magazine.*

"A complete digest of the most useful facts which constitute English law."—*Globe.*

"Admirably done, admirably arranged, and admirably cheap."—*Leeds Mercury.*

"A concise, cheap and complete epitome of the English law So plainly written that he who runs may read, and he who reads may understand."—*Figaro.*

"A dictionary of legal facts well put together. The book is a very useful one."—*Spectator.*

"The latest edition of this popular book ought to be in every business establishment, and on every library table."—*Sheffield Post.*

Private Bill Legislation and Provisional Orders.

HANDBOOK FOR THE USE OF SOLICITORS AND ENGINEERS Engaged in Promoting Private Acts of Parliament and Provisional Orders, for the Authorization of Railways, Tramways, Works for the Supply of Gas and Water, and other undertakings of a like character. By L. LIVINGSTON MACASSEY, of the Middle Temple, Barrister-at-Law, M.Inst.C.E.; Author of "Hints on Water Supply." 8vo, 950 pp., 25*s.* cloth.

"The volume is a desideratum on a subject which can be only acquired by practical experience, and the order of procedure in Private Bill Legislation and Provisional Orders is followed. The author's suggestions and notes will be found of great value to engineers and others professionally engaged in this class of practice."—*Building News.*

"The author's double experience as an engineer and barrister has eminently qualified him for the task, and enabled him to approach the subject alike from an engineering and legal point of view. The volume will be found a great help both to engineers and lawyers engaged in promoting Private Acts of Parliament and Provisional Orders."—*Local Government Chronicle.*

OGDEN, SMALE AND CO. LIMITED, PRINTERS, GREAT SAFFRON HILL, E.C.

WEALE'S RUDIMENTARY SCIENTIFIC SERIES.

Copio Lumen

*** The volumes of this Series are freely Illustrated with Woodcuts, or otherwise, where requisite. Throughout the following List it must be understood that the books are bound in limp cloth, unless otherwise stated; *but the volumes marked with a ‡ may also be had strongly bound in cloth boards for 6d. extra.*

N.B.—In ordering from this List it is recommended, as a means of facilitating business and obviating error, to quote the numbers affixed to the volumes, as well as the titles and prices.

CIVIL ENGINEERING, SURVEYING, ETC.

No.

31. *WELLS AND WELL-SINKING.* By JOHN GEO. SWINDELL, A.R.I.B.A., and G. R. BURNELL, C.E. Revised Edition. With a New Appendix on the Qualities of Water. Illustrated. 2s.

35. *THE BLASTING AND QUARRYING OF STONE*, for Building and other Purposes. By Gen. Sir J. BURGOYNE, Bart. 1s. 6d.

43. *TUBULAR, AND OTHER IRON GIRDER BRIDGES*, particularly describing the Britannia and Conway Tubular Bridges. By G. DRYSDALE DEMPSEY, C.E. Fourth Edition. 2s.

44. *FOUNDATIONS AND CONCRETE WORKS*, with Practical Remarks on Footings, Sand, Concrete, Béton, Pile-driving, Caissons, and Cofferdams, &c. By E. DOBSON. Seventh Edition. 1s. 6d.

60. *LAND AND ENGINEERING SURVEYING.* By T. BAKER, C.E. Fifteenth Edition, revised by Professor J. R. YOUNG. 2s.‡

80*. *EMBANKING LANDS FROM THE SEA.* With examples and Particulars of actual Embankments, &c. By J. WIGGINS, F.G.S. 2s.

81. *WATER WORKS*, for the Supply of Cities and Towns. With a Description of the Principal Geological Formations of England as influencing Supplies of Water, &c. By S. HUGHES, C.E. New Edition. 4s.‡

118. *CIVIL ENGINEERING IN NORTH AMERICA*, a Sketch of. By DAVID STEVENSON, F.R.S.E., &c. Plates and Diagrams. 3s.

167. *IRON BRIDGES, GIRDERS, ROOFS, AND OTHER WORKS.* By FRANCIS CAMPIN, C.E. 2s. 6d.‡

197. *ROADS AND STREETS.* By H. LAW, C.E., revised and enlarged by D. K. CLARK, C.E., including pavements of Stone, Wood, Asphalte, &c. 4s. 6d.‡

203. *SANITARY WORK IN THE SMALLER TOWNS AND IN VILLAGES.* By C. SLAGG, A.M.I.C.E. Revised Edition. 3s.‡

212. *GAS-WORKS, THEIR CONSTRUCTION AND ARRANGEMENT*; and the Manufacture and Distribution of Coal Gas. Originally written by SAMUEL HUGHES, C.E. Re-written and enlarged by WILLIAM RICHARDS, C.E. Eighth Edition, with important additions. 5s. 6d.‡

213. *PIONEER ENGINEERING.* A Treatise on the Engineering Operations connected with the Settlement of Waste Lands in New Countries. By EDWARD DOBSON, Assoc. Inst. C.E. 4s. 6d.‡

216. *MATERIALS AND CONSTRUCTION;* A Theoretical and Practical Treatise on the Strains, Designing, and Erection of Works of Construction. By FRANCIS CAMPIN, C.E. Second Edition, revised. 3s.‡

219. *CIVIL ENGINEERING.* By HENRY LAW, M.Inst. C.E. Including HYDRAULIC ENGINEERING by GEO. R. BURNELL, M.Inst. C.E. Seventh Edition, revised, with large additions by D. KINNEAR CLARK, M.Inst. C.E. 6s. 6d., Cloth boards, 7s. 6d.

268. *THE DRAINAGE OF LANDS, TOWNS, & BUILDINGS.* By G. D. DEMPSEY, C.E. Revised, with large Additions on Recent Practice in Drainage Engineering, by D. KINNEAR CLARK, M.I.C.E. Second Edition, Corrected. 4s. 6d.‡

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

MECHANICAL ENGINEERING, ETC.

33. *CRANES*, the Construction of, and other Machinery for Raising Heavy Bodies. By JOSEPH GLYNN, F.R.S. Illustrated. 1s. 6d.

34. *THE STEAM ENGINE*. By Dr. LARDNER. Illustrated. 1s. 6d.

59. *STEAM BOILERS:* their Construction and Management. By R. ARMSTRONG, C.E. Illustrated. 1s. 6d.

82. *THE POWER OF WATER*, as applied to drive Flour Mills, and to give motion to Turbines, &c. By JOSEPH GLYNN, F.R.S. 2s.‡

98. *PRACTICAL MECHANISM*, the Elements of; and Machine Tools. By T. BAKER, C.E. With Additions by J. NASMYTH, C.E. 2s. 6d.‡

139. *THE STEAM ENGINE*, a Treatise on the Mathematical Theory of, with Rules and Examples for Practical Men. By T. BAKER, C.E. 1s. 6d.

164. *MODERN WORKSHOP PRACTICE*, as applied to Steam Engines, Bridges, Ship-building, &c. By J. G. WINTON. New Edition. 3s. 6d.‡

165. *IRON AND HEAT*, exhibiting the Principles concerned in the Construction of Iron Beams, Pillars, and Girders. By J. ARMOUR. 2s. 6d.‡

166. *POWER IN MOTION:* Horse-Power, Toothed-Wheel Gearing, Long and Short Driving Bands, and Angular Forces. By J. ARMOUR, 2s.‡

171. *THE WORKMAN'S MANUAL OF ENGINEERING* DRAWING. By J. MAXTON. 7th Edn. With 7 Plates and 350 Cuts. 3s. 6d.‡

190. *STEAM AND THE STEAM ENGINE*, Stationary and Portable. By J. SEWELL and D. K. CLARK, C.E. 3s. 6d.‡

200. *FUEL*, its Combustion and Economy. By C. W. WILLIAMS. With Recent Practice in the Combustion and Economy of Fuel—Coal, Coke, Wood, Peat, Petroleum, &c.—by D. K. CLARK, M.I.C.E. 3s. 6d.‡

202. *LOCOMOTIVE ENGINES*. By G. D. DEMPSEY, C.E.; with large additions by D. KINNEAR CLARK, M.I.C.E. 3s.‡

211. *THE BOILERMAKER'S ASSISTANT* in Drawing, Templating, and Calculating Boiler and Tank Work. By JOHN COURTNEY, Practical Boiler Maker. Edited by D. K. CLARK, C.E. 100 Illustrations. 2s.

217. *SEWING MACHINERY:* Its Construction, History, &c., with full Technical Directions for Adjusting, &c. By J. W. URQUHART, C.E. 2s.‡

223. *MECHANICAL ENGINEERING*. Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Manufacture of the Steam Engine, &c. By FRANCIS CAMPIN, C.E. Second Edition. 2s. 6d.‡

236. *DETAILS OF MACHINERY*. Comprising Instructions for the Execution of various Works in Iron. By FRANCIS CAMPIN, C.E. 3s.‡

237. *THE SMITHY AND FORGE;* including the Farrier's Art and Coach Smithing. By W. J. E. CRANE. Illustrated. 2s. 6d.‡

238. *THE SHEET-METAL WORKER'S GUIDE;* a Practical Handbook for Tinsmiths, Coppersmiths, Zincworkers, &c. With 94 Diagrams and Working Patterns. By W. J. E. CRANE. Second Edition, revised. 1s. 6d.

251. *STEAM AND MACHINERY MANAGEMENT:* with Hints on Construction and Selection. By M. POWIS BALE, M.I.M.E. 2s. 6d.‡

254. *THE BOILERMAKER'S READY-RECKONER*. By J. COURTNEY. Edited by D. K. CLARK, C.E. 4s.

*** *Nos.* 211 *and* 254 *in One Vol., half-bound, entitled* "THE BOILERMAKER'S READY-RECKONER AND ASSISTANT." By J. COURTNEY and D. K. CLARK. 7s.

255. *LOCOMOTIVE ENGINE-DRIVING*. A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS, M.S.E Eighth Edition. 3s. 6d., limp; 4s. 6d. cloth boards.

256. *STATIONARY ENGINE-DRIVING*. A Practical Manual Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS, M.S.E. Fourth Edition. 3s. 6d. limp; 4s. 6d. cloth boards.

260. *IRON BRIDGES OF MODERATE SPAN:* their Construction and Erection. By HAMILTON W. PENDRED, C.E. 2s.

☞ *The ‡ indicates that these vols. may be had strongly bound at* 6*d. extra.*

MINING, METALLURGY, ETC.

4. *MINERALOGY,* Rudiments of; a concise View of the General Properties of Minerals. By A. RAMSAY, F.G.S., F.R.G.S., &c. Third Edition, revised and enlarged. Illustrated. 3s. 6d.‡

117. *SUBTERRANEOUS SURVEYING,* with and without the Magnetic Needle. By T. FENWICK and T. BAKER, C.E. Illustrated. 2s. 6d. ‡

135. *ELECTRO-METALLURGY;* Practically Treated. By ALEXANDER WATT. Ninth Edition, enlarged and revised, with additional Illustrations, and including the most recent Processes. 3s. 6d.‡

172. *MINING TOOLS,* Manual of. For the Use of Mine Managers, Agents, Students, &c. By WILLIAM MORGANS. 2s. 6d.

172*. *MINING TOOLS, ATLAS* of Engravings to Illustrate the above, containing 235 Illustrations, drawn to Scale. 4to. 4s. 6d.

176. *METALLURGY OF IRON.* Containing History of Iron Manufacture, Methods of Assay, and Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c. By H. BAUERMAN, F.G.S. Sixth Edition, revised and enlarged. 5s.‡

180. *COAL AND COAL MINING.* By the late Sir WARINGTON W. SMYTH, M.A., F.R.S. Seventh Edition, revised. 3s. 6d.‡ [*Just published.*

195. *THE MINERAL SURVEYOR AND VALUER'S COMPLETE GUIDE.* By W. LINTERN, M.E. Third Edition, including Magnetic and Angular Surveying. With Four Plates. 3s. 6d.‡

214. *SLATE AND SLATE QUARRYING,* Scientific, Practical, and Commercial. By D. C. DAVIES, F.G.S., Mining Engineer, &c. 3s.‡

264. *A FIRST BOOK OF MINING AND QUARRYING,* with the Sciences connected therewith, for Primary Schools and Self-Instruction. By J. H. COLLINS, F.G.S. Second Edition, with additions. 1s. 6d.

ARCHITECTURE, BUILDING, ETC.

16. *ARCHITECTURE—ORDERS*—The Orders and their Æsthetic Principles. By W. H. LEEDS. Illustrated. 1s. 6d.

17. *ARCHITECTURE—STYLES*—The History and Description of the Styles of Architecture of Various Countries, from the Earliest to the Present Period. By T. TALBOT BURY, F.R.I.B.A., &c. Illustrated. 2s.
*** ORDERS AND STYLES OF ARCHITECTURE, *in One Vol.*, 3*s*. 6*d*.

18. *ARCHITECTURE—DESIGN*—The Principles of Design in Architecture, as deducible from Nature and exemplified in the Works of the Greek and Gothic Architects. By E. L. GARBETT, Architect. Illustrated. 2s.6d.

*** *The three preceding Works, in One handsome Vol., half bound, entitled* "MODERN ARCHITECTURE," *price* 6*s.*

22. *THE ART OF BUILDING,* Rudiments of. General Principles of Construction, Materials used in Building, Strength and Use of Materials, Working Drawings, Specifications, and Estimates. By E. DOBSON, 2s.‡

25. *MASONRY AND STONECUTTING:* Rudimentary Treatise on the Principles of Masonic Projection and their application to Construction. By EDWARD DOBSON, M.R.I.B.A., &c. 2s. 6d.‡

42. *COTTAGE BUILDING.* By C. BRUCE ALLEN, Architect. Eleventh Edition, revised and enlarged. With a Chapter on Economic Cottages for Allotments, by EDWARD E. ALLEN, C.E. 2s.

45. *LIMES, CEMENTS, MORTARS, CONCRETES, MASTICS,* PLASTERING, &c. By G. R. BURNELL, C.E Fourteenth Edition. 1s. 6d.

57. *WARMING AND VENTILATION.* An Exposition of the General Principles as applied to Domestic and Public Buildings, Mines, Lighthouses, Ships, &c. By C. TOMLINSON, F.R.S., &c. Illustrated. 3s.

111. *ARCHES, PIERS, BUTTRESSES, &c.:* Experimental Essays on the Principles of Construction. By W. BLAND. Illustrated. 1s. 6d.

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

Architecture, Building, etc., *continued.*

116. *THE ACOUSTICS OF PUBLIC BUILDINGS;* or, The Principles of the Science of Sound applied to the purposes of the Architect and Builder. By T. ROGER SMITH, M.R.I.B.A., Architect. Illustrated. 1s. 6d.

127. *ARCHITECTURAL MODELLING IN PAPER*, the Art of. By T. A. RICHARDSON, Architect. Illustrated. 1s. 6d.

128. *VITRUVIUS—THE ARCHITECTURE OF MARCUS VITRUVIUS POLLO.* In Ten Books. Translated from the Latin by JOSEPH GWILT, F.S.A., F.R.A.S. With 23 Plates. 5s.

130. *GRECIAN ARCHITECTURE*, An Inquiry into the Principles of Beauty in; with an Historical View of the Rise and Progress of the Art in Greece. By the EARL OF ABERDEEN. 1s.

*** *The two preceding Works in One handsome Vol., half bound, entitled* "ANCIENT ARCHITECTURE," *price* 6*s.*

132. *THE ERECTION OF DWELLING-HOUSES.* Illustrated by a Perspective View, Plans, Elevations, and Sections of a pair of Semi-detached Villas, with the Specification, Quantities, and Estimates, &c. By S. H. BROOKS. New Edition, with Plates. 2s. 6d.‡

156. *QUANTITIES & MEASUREMENTS* in Bricklayers', Masons', Plasterers', Plumbers', Painters', Paperhangers', Gilders', Smiths', Carpenters' and Joiners' Work. By A. C. BEATON, Surveyor. Ninth Edition. 1s. 6d.

175. *LOCKWOOD'S BUILDER'S PRICE BOOK FOR* 1892. A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers, and Contractors. Re-constructed, Re-written, and further Enlarged. By FRANCIS T. W. MILLER, A.R.I.B.A. 700 pages. 3s. 6d.; cloth boards, 4s. [*Just Published.*

182. *CARPENTRY AND JOINERY*—THE ELEMENTARY PRINCIPLES OF CARPENTRY. Chiefly composed from the Standard Work of THOMAS TREDGOLD, C.E. With a TREATISE ON JOINERY by E. WYNDHAM TARN, M.A. Fifth Edition, Revised. 3s. 6d.‡

182*. *CARPENTRY AND JOINERY. ATLAS* of 35 Plates to accompany the above. With Descriptive Letterpress. 4to. 6s.

185. *THE COMPLETE MEASURER;* the Measurement of Boards, Glass, &c.; Unequal-sided, Square-sided, Octagonal-sided, Round Timber and Stone, and Standing Timber, &c. By RICHARD HORTON. Fifth Edition. 4s.; strongly bound in leather, 5s.

187. *HINTS TO YOUNG ARCHITECTS.* By G. WIGHTWICK. New Edition. By G. H. GUILLAUME. Illustrated. 3s. 6d.‡

188. *HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING:* with a Course of Elementary Drawing for House-Painters, Sign-Writers, &c., and a Collection of Useful Receipts. By ELLIS A. DAVIDSON. Sixth Edition. With Coloured Plates. 5s. cloth limp; 6s. cloth boards.

189. *THE RUDIMENTS OF PRACTICAL BRICKLAYING.* In Six Sections: General Principles; Arch Drawing, Cutting, and Setting; Pointing; Paving, Tiling, Materials; Slating and Plastering; Practical Geometry, Mensuration, &c. By ADAM HAMMOND. Seventh Edition. 1s. 6d.

191. *PLUMBING.* A Text-Book to the Practice of the Art or Craft of the Plumber. With Chapters upon House Drainage and Ventilation. Sixth Edition. With 380 Illustrations. By W. P. BUCHAN. 3s. 6d.‡

192. *THE TIMBER IMPORTER'S, TIMBER MERCHANT'S,* and BUILDER'S STANDARD GUIDE. By R. E. GRANDY. 2s.

206. *A BOOK ON BUILDING, Civil and Ecclesiastical,* including CHURCH RESTORATION. With the Theory of Domes and the Great Pyramid, &c. By Sir EDMUND BECKETT, Bart., LL.D., Q.C., F.R.A.S. 4s. 6d.‡

226. *THE JOINTS MADE AND USED BY BUILDERS* in the Construction of various kinds of Engineering and Architectural Works. By WYVILL J. CHRISTY, Architect. With upwards of 160 Engravings on Wood. 3s.‡

228. *THE CONSTRUCTION OF ROOFS OF WOOD AND IRON.* By E. WYNDHAM TARN, M.A., Architect. Second Edition, revised. 1s. 6d.

☞ *The ‡ indicates that these vols. may be had strongly bound at* 6*d. extra.*

Architecture, Building, etc., *continued.*

229. *ELEMENTARY DECORATION:* as applied to the Interior and Exterior Decoration of Dwelling-Houses, &c. By J. W. FACEY. 2s.

257. *PRACTICAL HOUSE DECORATION.* A Guide to the Art of Ornamental Painting. By JAMES W. FACEY. 2s. 6d.

*** *The two preceding Works, in One handsome Vol., half-bound, entitled* "HOUSE DECORATION, ELEMENTARY AND PRACTICAL," *price* 5s.

230. *HANDRAILING.* Showing New and Simple Methods for finding the Pitch of the Plank, Drawing the Moulds, Bevelling, Jointing-up, and Squaring the Wreath. By GEORGE COLLINGS. Second Edition, Revised, including A TREATISE ON STAIRBUILDING. Plates and Diagrams. 2s. 6d.

247. *BUILDING ESTATES:* a Rudimentary Treatise on the Development, Sale, Purchase, and General Management of Building Land. By FOWLER MAITLAND, Surveyor. Second Edition, revised. 2s.

248. *PORTLAND CEMENT FOR USERS.* By HENRY FAIJA, Assoc. M. Inst. C.E. Third Edition, corrected. Illustrated. 2s.

252. *BRICKWORK:* a Practical Treatise, embodying the General and Higher Principles of Bricklaying, Cutting and Setting, &c. By F. WALKER. Third Edition, Revised and Enlarged. 1s. 6d.

23. *THE PRACTICAL BRICK AND TILE BOOK.* Comprising:
189. BRICK AND TILE MAKING, by E. DOBSON, A.I.C.E.; PRACTICAL BRICKLAY-
265. ING, by A. HAMMOND; BRICKCUTTING AND SETTING, by A. HAMMOND. 534 pp. with 270 Illustrations. 6s. Strongly half-bound.

253. *THE TIMBER MERCHANT'S, SAW-MILLER'S, AND IMPORTER'S FREIGHT-BOOK AND ASSISTANT.* By WM. RICHARDSON. With a Chapter on Speeds of Saw-Mill Machinery, &c. By M. POWIS BALE, A.M.Inst.C.E. 3s.‡

258. *CIRCULAR WORK IN CARPENTRY AND JOINERY.* A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS. Second Edition, 2s. 6d.

259. *GAS FITTING:* A Practical Handbook treating of every Description of Gas Laying and Fitting. By JOHN BLACK. With 122 Illustrations. 2s. 6d.‡

261. *SHORING AND ITS APPLICATION:* A Handbook for the Use of Students. By GEORGE H. BLAGROVE. 1s. 6d.

265. *THE ART OF PRACTICAL BRICK CUTTING & SETTING.* By ADAM HAMMOND. With 90 Engravings. 1s. 6d. [*Just published.*

267. *THE SCIENCE OF BUILDING:* An Elementary Treatise on the Principles of Construction. Adapted to the Requirements of Architectural Students. By E. WYNDHAM TARN, M.A. Lond. Third Edition, Revised and Enlarged. With 59 Wood Engravings. 3s. 6d.‡

271. *VENTILATION:* a Text-book to the Practice of the Art of Ventilating Buildings, with a Supplementary Chapter upon Air Testing. By WILLIAM PATON BUCHAN, R.P., Sanitary and Ventilating Engineer, Author of "Plumbing," &c. 3s. 6d.‡ [*Just published.*

SHIPBUILDING, NAVIGATION, MARINE ENGINEERING, ETC.

51. *NAVAL ARCHITECTURE.* An Exposition of the Elementary Principles of the Science, and their Practical Application to Naval Construction. By J. PEAKE. Fifth Edition, with Plates and Diagrams. 3s. 6d.‡

53*. *SHIPS FOR OCEAN & RIVER SERVICE,* Elementary and Practical Principles of the Construction of. By H. A. SOMMERFELDT. 1s. 6d.

53**. *AN ATLAS OF ENGRAVINGS* to Illustrate the above. Twelve large folding plates. Royal 4to, cloth. 7s. 6d.

54. *MASTING, MAST-MAKING, AND RIGGING OF SHIPS,* Also Tables of Spars, Rigging, Blocks; Chain, Wire, and Hemp Ropes, &c., relative to every class of vessels. By ROBERT KIPPING, N.A. 2s.

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

Shipbuilding, Navigation, Marine Engineering, etc., *cont.*

54*. *IRON SHIP-BUILDING.* With Practical Examples and Details. By JOHN GRANTHAM, C.E. Fifth Edition. 4s.

55. *THE SAILOR'S SEA BOOK:* a Rudimentary Treatise on Navigation. By JAMES GREENWOOD, B.A. With numerous Woodcuts and Coloured Plates. New and enlarged edition. By W. H. ROSSER. 2s. 6d.‡

80. *MARINE ENGINES AND STEAM VESSELS.* By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with Additions by the Author and by GEORGE CARLISLE, C.E. 4s. 6d. limp; 5s. cloth boards.

83*bis*. *THE FORMS OF SHIPS AND BOATS.* By W. BLAND. Eighth Edition, Revised, with numerous Illustrations and Models. 1s. 6d.

99. *NAVIGATION AND NAUTICAL ASTRONOMY,* in Theory and Practice. By Prof. J. R. YOUNG. New Edition. 2s. 6d.

106. *SHIPS' ANCHORS,* a Treatise on. By G. COTSELL, N.A. 1s. 6d.

149. *SAILS AND SAIL-MAKING.* With Draughting, and the Centre of Effort of the Sails; Weights and Sizes of Ropes; Masting, Rigging, and Sails of Steam Vessels, &c. 12th Edition. By R. KIPPING, N.A., 2s. 6d.‡

155. *ENGINEER'S GUIDE TO THE ROYAL & MERCANTILE* NAVIES. By a PRACTICAL ENGINEER. Revised by D. F. M'CARTHY. 3s.

55 & 204. *PRACTICAL NAVIGATION.* Consisting of The Sailor's Sea-Book. By JAMES GREENWOOD and W. H. ROSSER. Together with the requisite Mathematical and Nautical Tables for the Working of the Problems. By H. LAW, C.E., and Prof. J. R. YOUNG. 7s. Half-bound.

AGRICULTURE, GARDENING, ETC.

61*. *A COMPLETE READY RECKONER FOR THE ADMEA-* SUREMENT OF LAND, &c. By A. ARMAN. Third Edition, revised and extended by C. NORRIS, Surveyor, Valuer, &c. 2s.

131. *MILLER'S, CORN MERCHANT'S, AND FARMER'S* READY RECKONER. Second Edition, with a Price List of Modern Flour-Mill Machinery, by W. S. HUTTON, C.E. 2s.

140. *SOILS, MANURES, AND CROPS.* (Vol. 1. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s.

141. *FARMING & FARMING ECONOMY,* Notes, Historical and Practical, on. (Vol. 2. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. 3s.

142. *STOCK; CATTLE, SHEEP, AND HORSES.* (Vol. 3. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s. 6d.

145. *DAIRY, PIGS, AND POULTRY,* Management of the. By R. SCOTT BURN. (Vol. 4. OUTLINES OF MODERN FARMING.) 2s.

146. *UTILIZATION OF SEWAGE, IRRIGATION, AND* RECLAMATION OF WASTE LAND. (Vol. 5. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s. 6d.

*** *Nos.* 140-1-2-5-6, *in One Vol., handsomely half-bound, entitled* "OUTLINES OF MODERN FARMING." By ROBERT SCOTT BURN. *Price* 12*s.*

177. *FRUIT TREES,* The Scientific and Profitable Culture of. From the French of DU BREUIL. Revised by GEO. GLENNY. 187 Woodcuts. 3s. 6d.‡

198. *SHEEP; THE HISTORY, STRUCTURE, ECONOMY, AND* DISEASES OF. By W. C. SPOONER, M.R.V.C., &c. Fifth Edition, enlarged, including Specimens of New and Improved Breeds. 3s. 6d.‡

201. *KITCHEN GARDENING MADE EASY.* By GEORGE M. F. GLENNY. Illustrated. 1s. 6d.‡

207. *OUTLINES OF FARM MANAGEMENT, and the Organization of Farm Labour.* By R. SCOTT BURN. 2s. 6d.‡

208. *OUTLINES OF LANDED ESTATES MANAGEMENT.* By R. SCOTT BURN. 2s. 6d.

*** *Nos.* 207 *&* 208 *in One Vol., handsomely half-bound, entitled* "OUTLINES OF LANDED ESTATES AND FARM MANAGEMENT." By R. SCOTT BURN. *Price* 6*s.*

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

Agriculture, Gardening, etc., *continued.*

209. *THE TREE PLANTER AND PLANT PROPAGATOR.* A Practical Manual on the Propagation of Forest Trees, Fruit Trees, Flowering Shrubs, Flowering Plants, &c. By SAMUEL WOOD. 2s.

210. *THE TREE PRUNER.* A Practical Manual on the Pruning of Fruit Trees, including also their Training and Renovation; also the Pruning of Shrubs, Climbers, and Flowering Plants. By SAMUEL WOOD. 1s. 6d.

*** *Nos.* 209 *&* 210 *in One Vol., handsomely half-bound, entitled* "THE TREE PLANTER, PROPAGATOR, AND PRUNER." By SAMUEL WOOD. *Price* 3*s.* 6d.

218. *THE HAY AND STRAW MEASURER:* Being New Tables for the Use of Auctioneers, Valuers, Farmers, Hay and Straw Dealers, &c. By JOHN STEELE. Fifth Edition. 2s.

222. *SUBURBAN FARMING.* The Laying-out and Cultivation of Farms, adapted to the Produce of Milk, Butter, and Cheese, Eggs, Poultry, and Pigs. By Prof. JOHN DONALDSON and R. SCOTT BURN. 3s. 6d.‡

231. *THE ART OF GRAFTING AND BUDDING.* By CHARLES BALTET. With Illustrations. 2s. 6d.‡

232. *COTTAGE GARDENING;* or, Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAY. 1s. 6d.

233. *GARDEN RECEIPTS.* Edited by CHARLES W. QUIN. 1s. 6d.

234. *MARKET AND KITCHEN GARDENING.* By C. W. SHAW, late Editor of "Gardening Illustrated." 3s.‡

239. *DRAINING AND EMBANKING.* A Practical Treatise, embodying the most recent experience in the Application of Improved Methods. By JOHN SCOTT, late Professor of Agriculture and Rural Economy at the Royal Agricultural College, Cirencester. With 68 Illustrations. 1s. 6d.

240. *IRRIGATION AND WATER SUPPLY.* A Treatise on Water Meadows, Sewage Irrigation, and Warping; the Construction of Wells, Ponds, and Reservoirs, &c. By Prof. JOHN SCOTT. With 34 Illus. 1s. 6d.

241. *FARM ROADS, FENCES, AND GATES.* A Practical Treatise on the Roads, Tramways, and Waterways of the Farm; the Principles of Enclosures; and the different kinds of Fences, Gates, and Stiles. By Professor JOHN SCOTT. With 75 Illustrations. 1s. 6d.

242. *FARM BUILDINGS.* A Practical Treatise on the Buildings necessary for various kinds of Farms, their Arrangement and Construction, with Plans and Estimates. By Prof. JOHN SCOTT. With 105 Illus. 2s.

243. *BARN IMPLEMENTS AND MACHINES.* A Practical Treatise on the Application of Power to the Operations of Agriculture; and on various Machines used in the Threshing-barn, in the Stock-yard, and in the Dairy, &c. By Prof. J. SCOTT. With 123 Illustrations. 2s.

244. *FIELD IMPLEMENTS AND MACHINES.* A Practical Treatise on the Varieties now in use, with Principles and Details of Construction, their Points of Excellence, and Management. By Professor JOHN SCOTT. With 138 Illustrations. 2s.

245. *AGRICULTURAL SURVEYING.* A Practical Treatise on Land Surveying, Levelling, and Setting-out; and on Measuring and Estimating Quantities, Weights, and Values of Materials, Produce, Stock, &c. By Prof. JOHN SCOTT. With 62 Illustrations. 1s. 6d.

*** *Nos.* 239 *to* 245 *in One Vol., handsomely half-bound, entitled* "THE COMPLETE TEXT-BOOK OF FARM ENGINEERING." By Professor JOHN SCOTT. *Price* 12*s.*

250. *MEAT PRODUCTION.* A Manual for Producers, Distributors, &c. By JOHN EWART. 2s. 6d.‡

266. *BOOK-KEEPING FOR FARMERS & ESTATE OWNERS.* By J. M. WOODMAN, Chartered Accountant. 2s. 6d. cloth limp; 3s. 6d. cloth boards.

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

MATHEMATICS, ARITHMETIC, ETC.

32. *MATHEMATICAL INSTRUMENTS*, a Treatise on; Their Construction, Adjustment, Testing, and Use concisely Explained. By J. F. HEATHER, M.A. Fourteenth Edition, revised, with additions, by A. T. WALMISLEY, M.I.C.E., Fellow of the Surveyors' Institution. Original Edition, in 1 vol., Illustrated. 2s.‡

*** *In ordering the above, be careful to say, "Original Edition" (No. 32), to distinguish it from the Enlarged Edition in 3 vols. (Nos. 168-9-70.)*

76. *DESCRIPTIVE GEOMETRY*, an Elementary Treatise on; with a Theory of Shadows and of Perspective, extracted from the French of G. MONGE. To which is added, a description of the Principles and Practice of Isometrical Projection. By J. F. HEATHER, M.A. With 14 Plates. 2s.

178. *PRACTICAL PLANE GEOMETRY:* giving the Simplest Modes of Constructing Figures contained in one Plane and Geometrical Construction of the Ground. By J. F. HEATHER, M.A. With 215 Woodcuts. 2s.

83. *COMMERCIAL BOOK-KEEPING.* With Commercial Phrases and Forms in English, French, Italian, and German. By JAMES HADDON, M.A., Arithmetical Master of King's College School, London. 1s. 6d.

84. *ARITHMETIC*, a Rudimentary Treatise on: with full Explanations of its Theoretical Principles, and numerous Examples for Practice. By Professor J. R. YOUNG. Eleventh Edition. 1s. 6d.

84*. A KEY to the above, containing Solutions in full to the Exercises, together with Comments, Explanations, and Improved Processes, for the Use of Teachers and Unassisted Learners. By J. R. YOUNG. 1s. 6d.

85. *EQUATIONAL ARITHMETIC*, applied to Questions of Interest, Annuities, Life Assurance, and General Commerce; with various Tables by which all Calculations may be greatly facilitated. By W. HIPSLEY. 2s.

86. *ALGEBRA*, the Elements of. By JAMES HADDON, M.A. With Appendix, containing miscellaneous Investigations, and a Collection of Problems in various parts of Algebra. 2s.

86*. A KEY AND COMPANION to the above Book, forming an extensive repository of Solved Examples and Problems in Illustration of the various Expedients necessary in Algebraical Operations. By J. R. YOUNG. 1s. 6d.

88. 89. *EUCLID*, THE ELEMENTS OF: with many additional Propositions and Explanatory Notes: to which is prefixed, an Introductory Essay on Logic. By HENRY LAW, C.E. 2s. 6d.‡

*** *Sold also separately, viz.:—*

88. EUCLID, The First Three Books. By HENRY LAW, C.E. 1s. 6d.
89. EUCLID, Books 4, 5, 6, 11, 12. By HENRY LAW, C.E. 1s. 6d.

90. *ANALYTICAL GEOMETRY AND CONIC SECTIONS*, By JAMES HANN. A New Edition, by Professor J. R. YOUNG. 2s.‡

91. *PLANE TRIGONOMETRY*, the Elements of. By JAMES HANN, formerly Mathematical Master of King's College, London. 1s. 6d.

92. *SPHERICAL TRIGONOMETRY*, the Elements of. By JAMES HANN. Revised by CHARLES H. DOWLING, C.E. 1s.

*** *Or with "The Elements of Plane Trigonometry," in One Volume*, 2s. 6d.

93. *MENSURATION AND MEASURING.* With the Mensuration and Levelling of Land for the Purposes of Modern Engineering. By T. BAKER, C.E. New Edition by E. NUGENT, C.E. Illustrated. 1s. 6d.

101. *DIFFERENTIAL CALCULUS*, Elements of the. By W. S. B. WOOLHOUSE, F.R.A.S., &c. 1s. 6d.

102. *INTEGRAL CALCULUS*, Rudimentary Treatise on the. By HOMERSHAM COX, B.A. Illustrated. 1s.

136. *ARITHMETIC*, Rudimentary, for the Use of Schools and Self-Instruction. By JAMES HADDON, M.A. Revised by A. ARMAN. 1s. 6d.

137. A KEY TO HADDON'S RUDIMENTARY ARITHMETIC. By A. ARMAN. 1s. 6d.

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

Mathematics, Arithmetic, etc., *continued.*

168. *DRAWING AND MEASURING INSTRUMENTS.* Including—I. Instruments employed in Geometrical and Mechanical Drawing, and in the Construction, Copying, and Measurement of Maps and Plans. II. Instruments used for the purposes of Accurate Measurement, and for Arithmetical Computations. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.

169. *OPTICAL INSTRUMENTS.* Including (more especially) Telescopes, Microscopes, and Apparatus for producing copies of Maps and Plans by Photography. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.

170. *SURVEYING AND ASTRONOMICAL INSTRUMENTS.* Including—I. Instruments Used for Determining the Geometrical Features of a portion of Ground. II. Instruments Employed in Astronomical Observations. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.

*** *The above three volumes form an enlargement of the Author's original work "Mathematical Instruments."* (*See No.* 32 *in the Series.*)

168.
169.
170. *MATHEMATICAL INSTRUMENTS.* By J. F. HEATHER, M.A. Enlarged Edition, for the most part entirely re-written. The 3 Parts as above, in One thick Volume. With numerous Illustrations. 4s. 6d.‡

158. *THE SLIDE RULE, AND HOW TO USE IT;* containing full, easy, and simple Instructions to perform all Business Calculations with unexampled rapidity and accuracy. By CHARLES HOARE, C.E. Sixth Edition. With a Slide Rule in tuck of cover. 2s. 6d.‡

196. *THEORY OF COMPOUND INTEREST AND ANNUITIES;* with Tables of Logarithms for the more Difficult Computations of Interest, Discount, Annuities, &c. By FÉDOR THOMAN. Fourth Edition. 4s.‡

199. *THE COMPENDIOUS CALCULATOR;* or, Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions; together with Useful Tables. By D. O'GORMAN. Twenty-seventh Edition, carefully revised by C. NORRIS. 2s. 6d., cloth limp; 3s. 6d., strongly half-bound in leather.

204. *MATHEMATICAL TABLES,* for Trigonometrical, Astronomical, and Nautical Calculations; to which is prefixed a Treatise on Logarithms. By HENRY LAW, C.E. Together with a Series of Tables for Navigation and Nautical Astronomy. By Prof. J. R. YOUNG. New Edition. 4s.

204*. *LOGARITHMS.* With Mathematical Tables for Trigonometrical, Astronomical, and Nautical Calculations. By HENRY LAW, M.Inst.C.E. New and Revised Edition. (Forming part of the above Work). 3s.

221. *MEASURES, WEIGHTS, AND MONEYS OF ALL NATIONS,* and an Analysis of the Christian, Hebrew, and Mahometan Calendars. By W. S. B. WOOLHOUSE, F.R.A.S., F.S.S. Seventh Edition, 2s. 6d.‡

227. *MATHEMATICS AS APPLIED TO THE CONSTRUCTIVE ARTS.* Illustrating the various processes of Mathematical Investigation, by means of Arithmetical and Simple Algebraical Equations and Practical Examples. By FRANCIS CAMPIN, C.E. Second Edition. 3s.‡

PHYSICAL SCIENCE, NATURAL PHILOSOPHY, ETC.

1. *CHEMISTRY.* By Professor GEORGE FOWNES, F.R.S. With an Appendix on the Application of Chemistry to Agriculture. 1s.

2. *NATURAL PHILOSOPHY,* Introduction to the Study of. By C. TOMLINSON. Woodcuts. 1s. 6d.

6. *MECHANICS,* Rudimentary Treatise on. By CHARLES TOMLINSON. Illustrated. 1s. 6d.

7. *ELECTRICITY;* showing the General Principles of Electrical Science, and the purposes to which it has been applied. By Sir W. SNOW HARRIS, F.R.S., &c. With Additions by R. SABINE, C.E., F.S.A. 1s. 6d.

7*. *GALVANISM.* By Sir W. SNOW HARRIS. New Edition by ROBERT SABINE, C.E., F.S.A. 1s. 6d.

8. *MAGNETISM;* being a concise Exposition of the General Principles of Magnetical Science. By Sir W. SNOW HARRIS. New Edition, revised by H. M. NOAD, Ph.D. With 165 Woodcuts. 3s. 6d.‡

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

Physical Science, Natural Philosophy, etc., *continued.*

11. *THE ELECTRIC TELEGRAPH;* its History and Progress; with Descriptions of some of the Apparatus. By R. SABINE, C.E., F.S.A. 3s.

12. *PNEUMATICS*, including Acoustics and the Phenomena of Wind Currents, for the Use of Beginners By CHARLES TOMLINSON, F.R.S. Fourth Edition, enlarged. Illustrated. 1s. 6d.

72. *MANUAL OF THE MOLLUSCA;* a Treatise on Recent and Fossil Shells. By Dr. S. P. WOODWARD, A.L.S. Fourth Edition. With Plates and 300 Woodcuts. 7s. 6d., cloth.

96. *ASTRONOMY.* By the late Rev. ROBERT MAIN, M.A. Third Edition, by WILLIAM THYNNE LYNN, B.A., F.R.A.S. 2s.

97. *STATICS AND DYNAMICS*, the Principles and Practice of; embracing also a clear development of Hydrostatics, Hydrodynamics, and Central Forces. By T. BAKER, C.E. Fourth Edition. 1s. 6d.

173. *PHYSICAL GEOLOGY*, partly based on Major-General PORTLOCK's "Rudiments of Geology." By RALPH TATE, A.L.S., &c. Woodcuts. 2s.

174. *HISTORICAL GEOLOGY*, partly based on Major-General PORTLOCK's "Rudiments." By RALPH TATE, A.L.S., &c. Woodcuts. 2s. 6d.

173 & 174. *RUDIMENTARY TREATISE ON GEOLOGY*, Physical and Historical. Partly based on Major-General PORTLOCK's "Rudiments of Geology." By RALPH TATE, A.L.S., F.G.S., &c. In One Volume. 4s. 6d.‡

183 & 184. *ANIMAL PHYSICS*, Handbook of. By Dr. LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, Lond. With 520 Illustrations. In One Vol. 7s. 6d., cloth boards.

*** *Sold also in Two Parts, as follows:—*

183. ANIMAL PHYSICS. By Dr. LARDNER. Part I., Chapters I.—VII. 4s.

184. ANIMAL PHYSICS. By Dr. LARDNER. Part II., Chapters VIII.—XVIII. 3s.

269. *LIGHT:* an Introduction to the Science of Optics, for the Use of Students of Architecture, Engineering, and other Applied Sciences. By E. WYNDHAM TARN, M.A. 1s. 6d. [*Just published.*

FINE ARTS.

20. *PERSPECTIVE FOR BEGINNERS.* Adapted to Young Students and Amateurs in Architecture, Painting, &c. By GEORGE PYNE. 2s.

40 *GLASS STAINING, AND THE ART OF PAINTING ON GLASS.* From the German of Dr. GESSERT and EMANUEL OTTO FROMBERG. With an Appendix on THE ART OF ENAMELLING. 2s. 6d.

69. *MUSIC*, A Rudimentary and Practical Treatise on. With numerous Examples. By CHARLES CHILD SPENCER. 2s. 6d.

71. *PIANOFORTE*, The Art of Playing the. With numerous Exercises & Lessons from the Best Masters. By CHARLES CHILD SPENCER. 1s. 6d.

69-71. *MUSIC & THE PIANOFORTE.* In one vol. Half bound, 5s.

181. *PAINTING POPULARLY EXPLAINED*, including Fresco, Oil, Mosaic, Water Colour, Water-Glass, Tempera, Encaustic, Miniature, Painting on Ivory, Vellum, Pottery, Enamel, Glass, &c. With Historical Sketches of the Progress of the Art by THOMAS JOHN GULLICK, assisted JOHN TIMBS, F.S.A. Sixth Edition, revised and enlarged. 5s.‡

186. *A GRAMMAR OF COLOURING*, applied to Decorative Painting and the Arts. By GEORGE FIELD. New Edition, enlarged and adapted to the Use of the Ornamental Painter and Designer. By ELLIS A. DAVIDSON. With two new Coloured Diagrams, &c. 3s.‡

246. *A DICTIONARY OF PAINTERS, AND HANDBOOK FOR* PICTURE AMATEURS; including Methods of Painting, Cleaning, Relining and Restoring, Schools of Painting, &c. With Notes on the Copyists and Imitators of each Master. By PHILIPPE DARYL. 2s. 6d.‡

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

INDUSTRIAL AND USEFUL ARTS.

23. *BRICKS AND TILES*, Rudimentary Treatise on the Manufacture of. By E. Dobson, M.R.I.B.A. Illustrated, 3s.‡

67. *CLOCKS, WATCHES, AND BELLS*, a Rudimentary Treatise on. By Sir Edmund Beckett, LL.D., Q.C. Seventh Edition, revised and enlarged. 4s. 6d. limp; 5s. 6d. cloth boards.

83**. *CONSTRUCTION OF DOOR LOCKS.* Compiled from the Papers of A. C. Hobbs, and Edited by Charles Tomlinson, F.R.S. 2s. 6d.

162. *THE BRASS FOUNDER'S MANUAL;* Instructions for Modelling, Pattern-Making, Moulding, Turning, Filing, Burnishing, Bronzing, &c. With copious Receipts, &c. By Walter Graham. 2s.‡

205. *THE ART OF LETTER PAINTING MADE EASY.* By J. G. Badenoch. Illustrated with 12 full-page Engravings of Examples. 1s. 6d.

215. *THE GOLDSMITH'S HANDBOOK*, containing full Instructions for the Alloying and Working of Gold. By George E. Gee, 3s.‡

225. *THE SILVERSMITH'S HANDBOOK*, containing full Instructions for the Alloying and Working of Silver. By George E. Gee. 3s.‡

*** *The two preceding Works, in One handsome Vol., half-bound, entitled* "The Goldsmith's & Silversmith's Complete Handbook," 7s.

249. *THE HALL-MARKING OF JEWELLERY PRACTICALLY CONSIDERED.* By George E. Gee. 3s.‡

224. *COACH BUILDING*, A Practical Treatise, Historical and Descriptive. By J. W. Burgess. 2s. 6d.‡

235. *PRACTICAL ORGAN BUILDING.* By W. E. Dickson, M.A., Precentor of Ely Cathedral. Illustrated. 2s. 6d.‡

262. *THE ART OF BOOT AND SHOEMAKING.* By John Bedford Leno. Numerous Illustrations. Third Edition. 2s.

263. *MECHANICAL DENTISTRY:* A Practical Treatise on the Construction of the Various Kinds of Artificial Dentures, with Formulæ, Tables, Receipts, &c. By Charles Hunter. Third Edition. 3s.‡

270. *WOOD ENGRAVING:* A Practical and Easy Introduction to the Study of the Art. By W. N. Brown. 1s. 6d.

MISCELLANEOUS VOLUMES.

36. *A DICTIONARY OF TERMS used in ARCHITECTURE, BUILDING, ENGINEERING, MINING, METALLURGY, ARCHÆOLOGY, the FINE ARTS, &c.* By John Weale. Sixth Edition. Revised by Robert Hunt, F.R.S. Illustrated. 5s. limp; 6s. cloth boards.

50. *THE LAW OF CONTRACTS FOR WORKS AND SERVICES.* By David Gibbons. Third Edition, enlarged. 3s.‡

112. *MANUAL OF DOMESTIC MEDICINE.* By R. Gooding, B.A., M.D. A Family Guide in all Cases of Accident and Emergency 2s.

112*. *MANAGEMENT OF HEALTH.* A Manual of Home and Personal Hygiene. By the Rev. James Baird, B.A. 1s.

150. *LOGIC*, Pure and Applied. By S. H. Emmens. 1s. 6d.

153. *SELECTIONS FROM LOCKE'S ESSAYS ON THE HUMAN UNDERSTANDING.* With Notes by S. H. Emmens. 2s.

154. *GENERAL HINTS TO EMIGRANTS.* 2s.

157. *THE EMIGRANT'S GUIDE TO NATAL.* By Robert James Mann, F.R.A.S., F.M.S. Second Edition. Map. 2s.

193. *HANDBOOK OF FIELD FORTIFICATION.* By Major W. W. Knollys, F.R.G.S. With 163 Woodcuts. 3s.‡

194. *THE HOUSE MANAGER:* Being a Guide to Housekeeping. Practical Cookery, Pickling and Preserving, Household Work, Dairy Management, &c. By An Old Housekeeper. 3s. 6d.‡

194, 112 & 112*. *HOUSE BOOK (The).* Comprising :—I. The House Manager. By an Old Housekeeper. II. Domestic Medicine. By R. Gooding, M.D. III. Management of Health. By J. Baird. In One Vol., half-bound, 6s.

☞ *The ‡ indicates that these vols. may be had strongly bound at 6d. extra.*

EDUCATIONAL AND CLASSICAL SERIES.

HISTORY.

1. **England, Outlines of the History of;** more especially with reference to the Origin and Progress of the English Constitution. By WILLIAM DOUGLAS HAMILTON, F.S.A., of Her Majesty's Public Record Office. 4th Edition, revised. 5s.; cloth boards, 6s.

5. **Greece, Outlines of the History of;** in connection with the Rise of the Arts and Civilization in Europe. By W. DOUGLAS HAMILTON, of University College, London, and EDWARD LEVIEN, M.A., of Balliol College, Oxford. 2s. 6d.; cloth boards, 3s. 6d.

7. **Rome, Outlines of the History of:** from the Earliest Period to the Christian Era and the Commencement of the Decline of the Empire. By EDWARD LEVIEN, of Balliol College, Oxford. Map, 2s. 6d.; cl. bds. 3s. 6d.

9. **Chronology of History, Art, Literature, and Progress,** from the Creation of the World to the Present Time. The Continuation by W. D. HAMILTON, F.S.A. 3s.; cloth boards, 3s. 6d.

50. **Dates and Events in English History,** for the use of Candidates in Public and Private Examinations. By the Rev. E. RAND. 1s.

ENGLISH LANGUAGE AND MISCELLANEOUS.

11. **Grammar of the English Tongue,** Spoken and Written. With an Introduction to the Study of Comparative Philology. By HYDE CLARKE, D.C.L. Fifth Edition. 1s. 6d.

12. **Dictionary of the English Language,** as Spoken and Written. Containing above 100,000 Words. By HYDE CLARKE, D.C.L. 3s. 6d.; cloth boards, 4s. 6d.; complete with the GRAMMAR, cloth bds., 5s. 6d.

48. **Composition and Punctuation,** familiarly Explained for those who have neglected the Study of Grammar. By JUSTIN BRENAN. 18th Edition. 1s. 6d.

49. **Derivative Spelling-Book:** Giving the Origin of Every Word from the Greek, Latin, Saxon, German, Teutonic, Dutch, French, Spanish, and other Languages; with their present Acceptation and Pronunciation. By J. ROWBOTHAM, F.R.A.S. Improved Edition. 1s. 6d.

51. **The Art of Extempore Speaking:** Hints for the Pulpit, the Senate, and the Bar. By M. BAUTAIN, Vicar-General and Professor at the Sorbonne. Translated from the French. 8th Edition, carefully corrected. 2s. 6d.

54. **Analytical Chemistry,** Qualitative and Quantitative, a Course of. To which is prefixed, a Brief Treatise upon Modern Chemical Nomenclature and Notation. By WM. W. PINK and GEORGE E. WEBSTER. 2s.

THE SCHOOL MANAGERS' SERIES OF READING BOOKS,

Edited by the Rev. A. R. GRANT, Rector of Hitcham, and Honorary Canon of Ely; formerly H.M. Inspector of Schools.

INTRODUCTORY PRIMER, 3*d.*

	s.	*d.*		*s.*	*d.*
FIRST STANDARD	0	6	FOURTH STANDARD	1	2
SECOND "	0	10	FIFTH "	1	6
THIRD "	1	0	SIXTH "	1	6

LESSONS FROM THE BIBLE. Part I. Old Testament. 1s.

LESSONS FROM THE BIBLE. Part II. New Testament, to which is added THE GEOGRAPHY OF THE BIBLE, for very young Children. By Rev. C. THORNTON FORSTER. 1s. 2d. *** Or the Two Parts in One Volume. 2s.

FRENCH.

24. **French Grammar.** With Complete and Concise Rules on the Genders of French Nouns. By G. L. STRAUSS, Ph.D. 1s. 6d.

25. **French-English Dictionary.** Comprising a large number of New Terms used in Engineering, Mining, &c. By ALFRED ELWES. 1s. 6d.

26. **English-French Dictionary.** By ALFRED ELWES. 2s.

25,26. **French Dictionary** (as above). Complete, in One Vol., 3s.; cloth boards, 3s. 6d. *** Or with the GRAMMAR, cloth boards, 4s. 6d.

47. **French and English Phrase Book:** containing Introductory Lessons, with Translations, several Vocabularies of Words, a Collection of suitable Phrases, and Easy Familiar Dialogues. 1s. 6d.

GERMAN.

39. **German Grammar.** Adapted for English Students, from Heyse's Theoretical and Practical Grammar, by Dr. G. L. STRAUSS. 1s. 6d.

40. **German Reader:** A Series of Extracts, carefully culled from the most approved Authors of Germany; with Notes, Philological and Explanatory. By G. L. STRAUSS, Ph.D. 1s.

41-43. **German Triglot Dictionary.** By N. E. S. A. HAMILTON. In Three Parts. Part I. German-French-English. Part II. English-German-French. Part III. French-German-English. 3s., or cloth boards, 4s.

41-43 & 39. **German Triglot Dictionary** (as above), together with German Grammar (No. 39), in One Volume, cloth boards, 5s.

ITALIAN.

27. **Italian Grammar,** arranged in Twenty Lessons, with a Course of Exercises. By ALFRED ELWES. 1s. 6d.

28. **Italian Triglot Dictionary,** wherein the Genders of all the Italian and French Nouns are carefully noted down. By ALFRED ELWES. Vol. 1. Italian-English-French. 2s. 6d.

30. **Italian Triglot Dictionary.** By A. ELWES. Vol. 2. English-French-Italian. 2s. 6d.

32. **Italian Triglot Dictionary.** By ALFRED ELWES. Vol. 3. French-Italian-English. 2s. 6d.

28,30, 32. **Italian Triglot Dictionary** (as above). In One Vol., 7s. 6d. Cloth boards.

SPANISH AND PORTUGUESE.

34. **Spanish Grammar,** in a Simple and Practical Form. With a Course of Exercises. By ALFRED ELWES. 1s. 6d.

35. **Spanish-English and English-Spanish Dictionary.** Including a large number of Technical Terms used in Mining, Engineering, &c. with the proper Accents and the Gender of every Noun. By ALFRED ELWES 4s.; cloth boards, 5s. *** Or with the GRAMMAR, cloth boards, 6s.

55. **Portuguese Grammar,** in a Simple and Practical Form. With a Course of Exercises. By ALFRED ELWES. 1s. 6d.

56. **Portuguese-English and English-Portuguese Dictionary.** Including a large number of Technical Terms used in Mining, Engineering, &c., with the proper Accents and the Gender of every Noun. By ALFRED ELWES. Second Edition, Revised, 5s.; cloth boards, 6s. *** Or with the GRAMMAR, cloth boards, 7s.

HEBREW.

46*. **Hebrew Grammar.** By Dr. BRESSLAU. 1s. 6d.

44. **Hebrew and English Dictionary,** Biblical and Rabbinical; containing the Hebrew and Chaldee Roots of the Old Testament Post-Rabbinical Writings. By Dr. BRESSLAU. 6s.

46. **English and Hebrew Dictionary.** By Dr. BRESSLAU. 3s.

44,46. 46*. **Hebrew Dictionary** (as above), in Two Vols., complete, with the GRAMMAR, cloth boards, 12s.

LATIN.

19. **Latin Grammar.** Containing the Inflections and Elementary Principles of Translation and Construction. By the Rev. THOMAS GOODWIN, M.A., Head Master of the Greenwich Proprietary School. 1s. 6d.

20. **Latin-English Dictionary.** By the Rev. THOMAS GOODWIN, M.A. 2s.

22. **English-Latin Dictionary**; together with an Appendix of French and Italian Words which have their origin from the Latin. By the Rev. THOMAS GOODWIN, M.A. 1s. 6d.

20,22. **Latin Dictionary** (as above). Complete in One Vol., 3s. 6d. cloth boards, 4s. 6d. *⁎* Or with the GRAMMAR, cloth boards, 5s. 6d.

LATIN CLASSICS. With Explanatory Notes in English.

1. **Latin Delectus.** Containing Extracts from Classical Authors, with Genealogical Vocabularies and Explanatory Notes, by H. YOUNG. 1s. 6d.

2. **Cæsaris** Commentarii de Bello Gallico. Notes, and a Geographical Register for the Use of Schools, by H. YOUNG. 2s.

3. **Cornelius Nepos.** With Notes. By H. YOUNG. 1s.

4. **Virgilii** Maronis Bucolica et Georgica. With Notes on the Bucolics by W. RUSHTON, M.A., and on the Georgics by H. YOUNG. 1s. 6d.

5. **Virgilii** Maronis Æneis. With Notes, Critical and Explanatory, by H. YOUNG. New Edition, revised and improved With copious Additional Notes by Rev. T. H. L. LEARY, D.C.L., formerly Scholar of Brasenose College, Oxford. 3s.

5* ——— Part 1. Books i.—vi., 1s. 6d.

5** ——— Part 2. Books vii.—xii., 2s.

6. **Horace**; Odes, Epode, and Carmen Sæculare. Notes by H. YOUNG. 1s. 6d.

7. **Horace**; Satires, Epistles, and Ars Poetica. Notes by W. BROWNRIGG SMITH, M.A., F.R.G.S. 1s. 6d.

8. **Sallustii** Crispi Catalina et Bellum Jugurthinum. Notes, Critical and Explanatory, by W. M. DONNE, B.A., Trin. Coll., Cam. 1s. 6d.

9. **Terentii** Andria et Heautontimorumenos. With Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 1s. 6d.

10. **Terentii** Adelphi, Hecyra, Phormio. Edited, with Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 2s.

11. **Terentii** Eunuchus, Comœdia. Notes, by Rev. J. DAVIES, M.A. 1s. 6d.

12. **Ciceronis** Oratio pro Sexto Roscio Amerino. Edited, with an Introduction, Analysis, and Notes, Explanatory and Critical, by the Rev JAMES DAVIES, M.A. 1s. 6d.

13. **Ciceronis** Orationes in Catilinam, Verrem, et pro Archia. With Introduction, Analysis, and Notes, Explanatory and Critical, by Rev. T. H. L. LEARY, D.C.L. formerly Scholar of Brasenose College, Oxford. 1s. 6d.

14. **Ciceronis** Cato Major, Lælius, Brutus, sive de Senectute, de Amicitia, de Claris Oratoribus Dialogi. With Notes by W. BROWNRIGG SMITH M.A., F.R.G.S. 2s.

16. **Livy**: History of Rome. Notes by H. YOUNG and W. B. SMITH, M.A. Part 1. Books i., ii., 1s. 6d.

16*. ——— Part 2. Books iii., iv., v., 1s. 6d.

17. ——— Part 3. Books xxi., xxii., 1s. 6d.

19. **Latin Verse Selections**, from Catullus, Tibullus, Propertius, and Ovid. Notes by W. B. DONNE, M.A., Trinity College, Cambridge. 2s.

20. **Latin Prose Selections**, from Varro, Columella, Vitruvius, Seneca, Quintilian, Florus, Velleius Paterculus, Valerius Maximus Suetonius, Apuleius, &c. Notes by W. B. DONNE, M.A. 2s.

21. **Juvenalis** Satiræ. With Prolegomena and Notes by T. H. S. ESCOTT, B.A., Lecturer on Logic at King's College, London. 2s.

GREEK.

14. **Greek Grammar**, in accordance with the Principles and Philological Researches of the most eminent Scholars of our own day. By HANS CLAUDE HAMILTON. 1s. 6d.

15,17. **Greek Lexicon.** Containing all the Words in General Use, with their Significations, Inflections, and Doubtful Quantities. By HENRY R. HAMILTON. Vol. 1. Greek-English, 2s. 6d.; Vol. 2. English-Greek, 2s. Or the Two Vols. in One, 4s. 6d.: cloth boards, 5s.

14,15,17. **Greek Lexicon** (as above). Complete, with the GRAMMAR, in One Vol., cloth boards, 6s.

GREEK CLASSICS. With Explanatory Notes in English.

1. **Greek Delectus.** Containing Extracts from Classical Authors, with Genealogical Vocabularies and Explanatory Notes, by H. YOUNG. New Edition, with an improved and enlarged Supplementary Vocabulary, by JOHN HUTCHISON, M.A., of the High School, Glasgow. 1s. 6d.

2, 3. **Xenophon's Anabasis**; or, The Retreat of the Ten Thousand. Notes and a Geographical Register, by H. YOUNG. Part 1. Books i. to iii., 1s. Part 2. Books iv. to vii., 1s.

4. **Lucian's Select Dialogues.** The Text carefully revised, with Grammatical and Explanatory Notes, by H. YOUNG. 1s. 6d.

5-12. **Homer**, The Works of. According to the Text of BAEUMLEIN. With Notes, Critical and Explanatory, drawn from the best and latest Authorities, with Preliminary Observations and Appendices, by T. H. L. LEARY, M.A., D.C.L.

THE ILIAD:	Part 1. Books i. to vi., 1s. 6d.	Part 3. Books xiii. to xviii., 1s. 6d
	Part 2. Books vii. to xii., 1s. 6d.	Part 4. Books xix. to xxiv., 1s. 6d.
THE ODYSSEY:	Part 1. Books i. to vi., 1s. 6d	Part 3. Books xiii. to xviii., 1s. 6d.
	Part 2. Books vii. to xii., 1s. 6d.	Part 4. Books xix. to xxiv., and Hymns, 2s.

13. **Plato's Dialogues**: The Apology of Socrates, the Crito, and the Phædo. From the Text of C. F. HERMANN. Edited with Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 2s.

14-17. **Herodotus**, The History of, chiefly after the Text of GAISFORD. With Preliminary Observations and Appendices, and Notes, Critical and Explanatory, by T. H. L. LEARY, M.A., D.C.L.
Part 1. Books i., ii. (The Clio and Euterpe), 2s.
Part 2. Books iii., iv. (The Thalia and Melpomene), 2s.
Part 3. Books v.-vii. (The Terpsichore, Erato, and Polymnia), 2s.
Part 4. Books viii., ix. (The Urania and Calliope) and Index, 1s. 6d.

18. **Sophocles**: Œdipus Tyrannus. Notes by H. YOUNG. 1s.

20. **Sophocles**: Antigone. From the Text of DINDORF. Notes, Critical and Explanatory, by the Rev. JOHN MILNER, B.A. 2s.

23. **Euripides**: Hecuba and Medea. Chiefly from the Text of DINDORF. With Notes, Critical and Explanatory, by W. BROWNRIGG SMITH, M.A., F.R.G.S. 1s. 6d.

26. **Euripides**: Alcestis. Chiefly from the Text of DINDORF. With Notes, Critical and Explanatory, by JOHN MILNER, B.A. 1s. 6d.

30. **Æschylus**: Prometheus Vinctus: The Prometheus Bound. From the Text of DINDORF. Edited, with English Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 1s.

32. **Æschylus**: Septem Contra Thebes: The Seven against Thebes. From the Text of DINDORF. Edited, with English Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 1s.

40. **Aristophanes**: Acharnians. Chiefly from the Text of C. H. WEISE. With Notes, by C. S. T. TOWNSHEND, M.A. 1s. 6d.

41. **Thucydides**: History of the Peloponnesian War. Notes by H. YOUNG. Book 1. 1s. 6d.

42. **Xenophon's Panegyric on Agesilaus.** Notes and Introduction by LL. F. W. JEWITT. 1s. 6d.

43. **Demosthenes.** The Oration on the Crown and the Philippics. With English Notes. By Rev. T. H. L. LEARY, D.C.L., formerly Scholar of Brasenose College, Oxford. 1s. 6d.

2 6 n t

MANUALS FOR SPECIAL TRADES AND INDUSTRIES.

MISCELLANEOUS.

THE ART OF SOAP MAKING: A Practical Handbook of the Manufacture of Hard and Soft Soaps, Toilet Soaps, &c. Including many New Processes. By ALEX. WATT. Fourth Edition, Revised and Enlarged. Crown 8vo, 7s. 6d. cloth.

THE ART OF PAPER MAKING: A Practical Handbook on the Manufacture of Paper from Rags, Esparto, Straw and other Fibrous Materials. By ALEX. WATT. Crown 8vo, 7s. 6d. cloth.

THE ART OF LEATHER MANUFACTURE: A Practical Handbook, in which the Operations of Tanning, Currying and Leather Dressing are fully Described, and the Principles of Tanning Explained and many Recent Processes Introduced. By ALEX. WATT. Second Edition. Crown 8vo, 9s. cloth.

THE ART OF BOOT AND SHOE MAKING: A Practical Handbook, including Measurement, Last-Fitting, Cutting-Out, Closing and Making. By JOHN B. LENO. Third Edition. 12mo, 2s. cloth.

THE MANUAL OF COLOURS AND DYE-WARES: Their Properties, Applications, Valuation, Impurities and Sophistications. By J. W. SLATER. Second Edition, Revised. Cr. 8vo, 7s. 6d. cloth.

COACH-BUILDING: A Practical Treatise, Historical and Descriptive. Containing full Information of the various Trades and Processes Involved. By J. W. BURGESS. 12mo, 2s. 6d. cloth.

PRACTICAL ORGAN BUILDING. By W. E. DICKSON, M.A., Precentor of Ely Cathedral. Second Edition, Revised, with Additions. 12mo, 2s. 6d. cloth.

THE BREAD AND BISCUIT BAKER'S AND SUGAR-BOILER'S ASSISTANT. Including a large variety of Modern Recipes. By R. WELLS. Second Edition. Crown 8vo, 2s. cloth.

THE PASTRYCOOK AND CONFECTIONER'S GUIDE. For Hotels, Restaurants and the Trade in general. By R. WELLS. Crown 8vo, 2s. cloth.

ORNAMENTAL CONFECTIONERY: A Guide for Bakers, Confectioners and Pastrycooks; including a variety of Modern Recipes and Remarks on Decorative and Coloured Work. With 129 Original Designs. By R. WELLS. Crown 8vo, 5s. cloth gilt.

THE MODERN FLOUR CONFECTIONER, Wholesale and Retail. Containing a large Collection of Recipes for Cheap Cakes, Biscuits, &c. By R. WELLS. Crown 8vo, 2s. cloth.

RUBBER HAND STAMPS AND THE MANIPULATION OF RUBBER: A Practical Treatise on the Manufacture of Indiarubber Hand Stamps, Small Articles of Indiarubber and Allied Subjects. By T. O'CONOR SLOANE. Crown 8vo, 5s. cloth.

CROSBY LOCKWOOD & SON, 7, Stationers' Hall Court, E.C.